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MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME I.—THE ECHINOIDEA.

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PREFACE.

With this Preface the history of the British Fossil Cretaceous Echinoidea is brought to a close, and it only remains for the Author to record his warmest acknowledgments to the many kind friends, enumerated in the retrospect, who have generously assisted him in his long and laborious task. The duty imposed upon him by the Council of the Palæontographical Society, occasioned by the untimely death of his distinguished colleague, Prof. Edw. Forbes, F.R.S., has been much lightened by their ready, willing, and friendly aid at all times.

When the Plates for this Monograph had been nearly completed his accomplished artist, Mr. Charles Bone, who had assisted him during so many years, likewise passed away; so that in writing this preface the Author is solemnly reminded of the mutability of all human undertakings, and desires to express his deep regret that one who had aided him for nearly thirty years by steady, continuous, and most accurate work, had not been spared to see the conclusion of his labours. The Author, therefore, embraces the present opportunity of recording his high appreciation of Mr. Bone's artistic drawings, which for beauty and accuracy in lithographic art have not been surpassed, whilst all essential details relating to the anatomical structure of the Echinoidea have been faithfully rendered throughout.

The Author in an especial manner desires to return his warmest acknowledgment and very best thanks to his old friend the Rev. Professor Wiltshire, F.G.S., the indefatigable Secretary of the Palæontographical Society, for his unwearied attention to every part of his work as it passed in successive years through the press. The admirable summary of the British Cretaceous Echinoidea and copious index which he has kindly contributed to complete this volume, have added much to its value and general usefulness; and he must further add that the liberal

supply of fine specimens from his rich collection of Chalk Echinoderms, in order to furnish the artist with the best possible specimens for the plates, has been of very great assistance in carrying out the work, and for which he now expresses his deep obligations, and records his lasting gratitude for all his most kind, generous, and friendly aid from first to last.

4, St. Margaret's Terrace, Cheltenham;
25*th April*, 1882.

A RETROSPECT.

Before bringing this Monograph to a termination I desire to state to my Readers (many of whom have joined our Society since the work was commenced), the circumstances under which I became the historian of the British Cretaceous Echinodermata, and the difficulties I experienced and had to overcome during the progress of its composition, as they help to explain the apparent delay that has occurred and the length of time which has elapsed between the issue of the first and last part of the Monograph.

When the History of the British Fossil Echinodermata was first proposed to the Council of the Palæontographical Society in 1851, by the late Professor Edward Forbes, it was arranged that the description of the Cretaceous species was to be undertaken by him, and that of the Jurassic species by myself. Long, however, before the Jurassic portion was complete my highly esteemed and learned colleague died (in November, 1854), very soon after he had attained the object of his life's ambition, the Chair of Natural History in the University of Edinburgh. Before leaving London, Professor Forbes had gathered from various sources a large collection of materials for the Cretaceous Monograph; these he took with him to Edinburgh, intending to commence the work as soon as he had settled down into the routine duties of his new chair; but his sudden death unfortunately deprived science of the rich store of facts and notes on the specimens he had collected from various cabinets for this work. Under these painful circumstances the Council of the Palæontographical Society urged me to undertake the description of the Cretaceous forms as soon as I had finished the Jurassic species; and this I consented to do in the belief that the materials collected by Professor Forbes would be available for the work. On making inquiry, however, I found to my dismay that after the death of my friend the fossils had been packed up with other property and sent into the cellars of the University, and could not be touched until some legal matters were arranged. A long delay now took place; and at last, when a search was made, the cases containing the Cretaceous specimens of Echinides could not be found. In this dilemma, and not then having a good collection of Chalk Urchins myself (all my energies up to that time having been given to complete my Jurassic collection), I applied to the authorities of the British Museum, to the Director of the Museum of Practical Geology (the late Sir Roderick Murchison); and to the Earl of Ducie, the Rev. Thos. Wiltshire, the late Dr. Bowerbank, the late Professor Tennant, the late Dr. S. Woodward, Mr. W. Cunnington,

Major Cockburn, Mr. Caleb Evans, Mr. Robert Etheridge, and Mr. Weist. Messrs. E. T. Newton and Sharman, Assistant Naturalists of the Jermyn Street Museum, most kindly at all times aided me in making selections of specimens for figuring in the plates.

On the Continent I have had much friendly aid from MM. Gustave Cotteau, of Auxerre, Perceval de Loriol, of Geneva, Herr Struckmann, of Hanover, Professor De Koninck, of Liège, and the late MM. Seemann and Triger, of Paris.

In addition to the valuable aid of the above kind friends, to whom individually and collectively I tender my warmest thanks, I have made many tours of inspection to all the best private collections in England containing Chalk Echinoderms, and have visited and worked the quarries in the different Cretaceous formations, in order to identify the distribution of the species with the beds from whence they were said to have been collected. All these proceedings have occupied much time, and were undertaken at a period when I was fully occupied in the laborious practice of my profession, so that I found much difficulty in bringing out the parts consecutively in the annual volumes of the Palæontographical Society.

The many duties and incessant occupation connected with my present position as Medical Officer of Health having deprived me of the leisure necessary to continue my sketch of the History of Echinology, I ventured to ask my much esteemed friend, M. Perceval de Loriol (author of the 'Echinologie Helvetique'), to undertake this portion of the work. Monsieur de Loriol, with his usual kindness, consented to do so, I have, therefore, now the pleasure of introducing his masterly sketch (for the translation of which I alone am responsible) of the progress made in Echinology during the last twenty years. For this most valuable addition to my work I beg to return my highly accomplished friend my very warmest thanks.

"On the History of Echinology since 1862, by Perceval de Loriol.

The fourth part of the vast Monograph, undertaken by Dr. Wright, relating to the description of the Jurassic Echinides, was published in 1861. Dr. Wright had enriched that part with a Table, giving a list of the works concerning the Echinides, that had come to his knowledge up to that date. It will not be without interest and utility, therefore, to terminate the Monograph on the Cretaceous Echinides, to which Dr. Wright is now adding the last pages, with a rapid review of the progress which has been accomplished during the last twenty years in the domain of Echinology, and to take a glance at the magnificent discoveries for which we are indebted to the late Expeditions, which had for their object the investigations of the depths of the sea.

Dr. Wright's numerous professional occupations not permitting him to enter upon this branch of the subject, he has asked me to take it upon myself, and it is with very great pleasure that I embrace the occasion of co-operating, in however feeble a degree, in a great and beautiful work, brought so happily to a conclusion by my learned friend.

Commencing with an enumeration of the many works written on the Fossil Echinides, I think we shall proceed with more method if they be grouped by countries and by regions, taking into consideration, not the nationality of the authors, but the Echinitic fauna upon which they have made their observations.[1]

The study of the Fossil Echinides of Great Britain appears during late years to be concentrated in the general Monograph by Dr. Wright, and I find myself able to cite only one paper, that by Mr. Keeping (1), 'On the Genus *Pelanechinus*, a new Section established for the *Hemipedina corallina*, Wright,' the coronal plates of which appear to have been in some measure imbricated, resembling those in *Asthenosoma*.

France has contributed a great number of works on Echinology, of which most are due to the indefatigable zeal and untiring industry of M. Gustave Cotteau, of Auxerre; and it is important to mention above all a work of the first order, the 'Echinides de la Paléontologie Française' (2), the publication of which is still being actively carried on.

The 'Échinides Crétacés,' commenced by d'Orbigny and continued by M. Cotteau, is now completed. Two volumes of the 'Échinides Jurassiques' have already appeared. They comprise the *Echinides irréguliers*, the family of the CIDARIDÆ, and those of the SALENIADÆ; those of the DIADEMATIDÆ will soon follow. Three other very important works of M. Cotteau, commenced many years ago, have been completed; the description of the Echinides of the Department of the Sarthe (3), in which he has made known the Urchins, so numerous and varied, which the Jurassic and Cretaceous strata of this Department contain, and the illustrations of which required sixty-five plates; the second part of the 'Echinides of the Yonne' (4), comprising the description and figures of ninety-nine species from the Terrains Crétacés; and lastly the first series of new or little known Echinides, which have successively appeared in the 'Revue et Magasin de Zoologie' (5), and in which are found valuable observations upon known species, as well as the description of numerous new species, the most part derived from France, but also from other countries. Independently of these works, as a whole, M. Cotteau has published many local Monographs, which have made great steps towards an exact know-

[1] To avoid the incumbrance of notes I shall add an appendix to this essay, in which I shall give the titles of the works to be identified by corresponding figures in the text. I have not cited all the works in which Fossil Echinides are mentioned, but only those which appear to me more specially important either as general works on the subject, or those in which some discovery is recorded. To this end I have made as conscientious an investigation of all the works as was in my power; but possibly some publications may have escaped my notice. If such should be the case I make an honorable amende in advance for the omission which I shall be the first to regret.

ledge of the Echinitic Fauna of France. These contributions are in the form of notes, or lists of species, with observations made to clear up critical questions, with sometimes more complete studies on which the species are found entirely described and figured. M. Cotteau has thus made known successively the Nummulitic Echinides of Biarritz (6); the Cretaceous Urchins of Martigues (7); the Echinides of the Pyrenees (8); those of the Aube (9); and those of the Oxfordian of the Ardèche (10); new species from the Environs of Bordeaux (11); the Echinides of the Cretaceous Colony of the "Garonnien" of the Department of Aude (12), among which was found the first Cretaceous *Schizaster* known; those of the Miocene deposits of Corsica (13); those of the Jurassic strata of Normandy (14); and lastly, a supplementary note (15) completes the characteristics of the curious new genus *Tetracidaris*, from the Neocomian of Central France, which possesses two series of pairs of pores in each poriferous zone, and four series of inter-amubulacral plates. In addition to these beautiful monographic studies of M. Cotteau, there are other works upon the Echinides of France, which still remain to be enumerated. Thus, Saemann and Dollfuss, in 1861, characterised with care some species from Trouville (16). Dumortier, in his remarkable work upon the 'Depôts Jurassiques du Bassin du Rhône,' has described many Echinides from the Lias (17). M. Tournouer (18), has given a revision of the Echinides of the Calcaire à Astéries (Tongrian) of the South-west of France, with figures of new species and critical remarks on the same. Caffin (19) has occupied himself with the Echinides of the Environs of Evreux. M. Bucaille (20) has given a Catalogue Raissonné of those of the Seine Inférieure, with descriptions of new species. Professor Hébert (21) has endeavoured accurately to diagnose the characters of certain Hemiasters, and he has (22) described two new *Hemipneustes* from the Chalk of the Pyrenees. M. Sauvage (23) has made known new species from the Upper Jurassic of the Boulonnais. M. Arnaud (24) has endeavoured to facilitate the determination of the numerous Cretaceous species of the genus *Cyphosoma*, to which he has added some new forms. Desmoulins (25), to whom Echinology was already indebted for numerous works, has made some interesting observations upon six species of *Echinolampas*, upon the spines of *Echinocidaris*, and upon a Miocene *Spatangus* from Saucats. Finally, I have published (26) a description of some Echinides from Berrias and Aizy (27), and have been occupied with those from the Portlandian of the Yonne (28), also with those from the Upper Jurassic of the Boulonnais (29), and of the Haute Marne (30). A general work, by Dujardin and Hupè, upon the Echinoderms (31) has likewise to be mentioned.

In Switzerland the Echinologic studies, to which Agassiz and Desor had already given such vigorous impulsion, have been continued. Etallon (32), who had already studied the Echinides from different formations bordering on the frontiers of France (33 and 34) and of Switzerland, aided in the enlargement of a posthumous work of Thurmann's, 'Le Lethæa Bruntrutana' (35), in which numerous species of Echinides are found described and figured. M. Ooster (36) a few years afterwards published his

'Synopsis of Fossil Echinoderms of the Swiss Alps,' in which numerous species from the Nummulitic formation are found figured. He has given also indications of certain Alpine species in his 'Protozoa Helvetica' (37). I have described also some Echinides from the Neocomian of Mont Salève (39), from the Valangian of Arzier (40), and the Urgonian of Landeron (41). I have also undertaken, under the title of 'Echinologie Helvetique' (42), the publication of the Fossil Urchins of Switzerland. In the First Part comprehending the Jurassic Echinides I had the happiness of having for my collaborator M. Desor. I afterwards finished alone the Second and Third Parts, which treat of the Cretaceous and Tertiary Echinides. Four hundred and thirty-eight species are the contingent of the Echinitic fauna furnished up to the present time by the Secondary and Tertiary formations of Switzerland.

Thanks to M. Cotteau, the Fossil Echinides of Belgium, hitherto known in a very summary manner, have been submitted to a new and very necessary revision. He has published, in succession, a 'Note on the Cretaceous Echinides of Hainaut' (43), with some species figured; the 'Description of the Echinides of the Calcaire Grossier' of Mons, Senonian (44); and the 'Description of the Tertiary Echinides of Belgium' (45), an important Monograph, in which thirty-one species are found figured and described, and of which thirteen species only were previously known, and the most of these very imperfectly.

It is likewise to M. Cotteau that we owe the knowledge of three interesting species from the Upper Chalk of Sweden (46).

Among the works which have appeared on the Echinides of Germany it behoves me to cite, in the first place, the volume on the 'History of Fossils of Germany,' which Professor Quenstedt has devoted to the Echinides (47). The Atlas of twenty-eight plates contains no less than 1700 figures, with numerous magnified views; whilst the text treats of not only the Echinides of Germany, but also many others which are not found there. This work, the result of very considerable labour, comprehends a great number of useful indications and previous observations; but it is to be regretted that Professor Quenstedt persists in his refusal to accept the nomenclature adopted in the mean time by all authors and corresponding to the actual state of our knowledge. The want of method and the improper denominations occasion much confusion, so that the practical utility of the work is much diminished. "Die Echiniden" has, nevertheless, a real value, and has advanced science principally in making known several details of the structure of many species which had not been previously observed, and in many cases it will be consulted with advantage. The Chalk of the North of Germany has furnished to M. Schlüter (48) many new species which he has described and figured. Subsequently he indicated some others, but only gave short diagnoses of them (49). Besides, many of the Cretaceous species from the same region have been well figured and described by Schlœnbach (50); and M. Dames has given a description of the Jurassic species collected in the North-west of Germany. The Echinides of the Upper Cretaceous strata of the Valley of the Elbe have been described and figured by Prof.

Geinitz (52); and M. Schafhäutl has given figures of the Tertiary species from Kressenberg, but in general they have not been determined in a correct manner. It is important moreover to cite the new 'Handbuch der Palæontologie' by Prof. Zittel (54), and especially the well-written chapter treating of Echinoderms.

For the Empire of Austria I have equally many Echinologic works to mention. M. Cotteau (55) has made known the Echinides of Stramberg, derived from the strata about which so much controversy has taken place. M. Laube has decribed those from the Bathonian stage at Balin (56), and those from the Upper Tertiaries of Austro-Hungary; and he has discovered in the Eocene of the Mattsee (58) a new genus, the *Oolaster* bordering on *Ananchytes*. The Miocene strata of Ottnang have furnished to Herr R. Höerness (59) some species; and from those of the environs of Felmenes some others have been noted by Herr Loczy (60), amongst others a new and interesting *Echinocardium*.

The Urchins from the Eocene deposits of Hungary and Transylvania have been studied by Herr Pavay (61), who had undertaken a general Monograph on the Echinides of Hungary (62), of which his premature death only permitted him to give a first part to the world.

The Cretaceous strata, but especially the Tertiary beds, of Istria and of Friuli (64) have furnished many Echinides to M. Taramelli. His summary descriptions have been completed by M. Bittner (65), who has also enriched the Tertiary fauna of Istro-Dalmatia with new and interesting species.

The Tertiary strata of a region bordering upon Lombardy have been for a long time celebrated for their richness in Echinides, but a monographic study has not yet been made of them. Herr Schauroth (66), in his Catalogue of the Museum of Coburg, has made known in a very imperfect manner some new species. Herr Laube (67) has much augmented the number of forms, and grouping the whole of the known species, has endeavoured to establish a parallelism amongst the beds in which they are found. Herr Dames (68), following up these observations in a very extended memoir, has revised certain of Herr Laube's species, added new ones to the list, and established two new interesting groups:—the genus *Ilarionia*, which approaches *Pygorhynchus*, but possesses a pentagonal periostome; afterwards the curious genus *Oviclypeus*, which approaches very near to *Conoclypeus*, and like it, was provided with a masticatory apparatus. It behoves us still to cite a fossil species of the genus *Palæopneustes* recently discovered in the Seas of the Antilles. The Tertiary beds of the Vicentin seem to be almost inexhaustible, for Herr Bittner (65), following up the precited memoir with another, has been able to add many more species, among which he has discovered several new forms that were unknown to his predecessors.

The Miocene Mollusca of Italy have yielded to M. Manzoni (69, 70) many interesting Echinides; and in the Middle Miocene he has collected a large and curious species of *Spatangidæ* (71, 72). M. Gemellaro (73) has described some species from the Upper

Sequanian of Sicily; and the Abbé Stoppani (74) has described some species from the Lower Lias of Lombardy.

Regarding the Echinides of Spain I have only a few remarks to make. There are two works by M. Cotteau, one very short, relative to some new Echinides collected in Spain by M. de Verneuil (75), and the other being a contribution to a memoir of M. Barrois upon the Cretaceous strata of the Province of Oviedo, giving a description of some new Echinides from the Urgonian (76).

The Echinitic fauna from the Miocene beds of the Island of Malta, which is very rich in fossil Urchins in a fine state of preservation, had been previously studied and reported upon by Dr. Wright (77). These fossils were subsequently the subject of a second memoir, in which are additional notes, and the description and figures of some new species. In the Island of Melos a very interesting little Echinitic fauna has been found, apparently of Pliocene age, and in which Herr Dames has discovered a *Cidaris*, very different from those which now live in the Mediterranean (78).

Before terminating my remarks relating to Europe I have still to mention a little work which I have made on the Tertiary and Cretaceous Echinides brought from the Crimea, by M. Ernest Favre (79).

Crossing now the Mediterranean to pass into Africa we arrive in Algeria, which appears to be the promised land to the Echinologist, for in almost all the geological formations of this region the Echinides abound in a surprising manner. M. Coquand (80), in his 'Palæontology of the Province of Constantine,' first made known a great number of species. Afterwards came the large and beautiful publication of MM. Cotteau, Péron, and Gauthier (81), which, commencing with the Jurassic strata, undertakes to describe all the Fossil Echinides of Algiers; this work has now reached the Senonian stage of the Cretaceous deposits. Among the numerous species which these rocks have yielded, the number of those appertaining to the genus *Hemiaster* is truly extraordinary. In a recent work by M. Coquand (82), a great number of additional species of the same genus are described, but unfortunately not figured, hence it is impossible to give an exact account of the value of their characters.

I am of opinion that a general revision of the species would result in diminishing the number, for I cannot but suspect that sufficient allowance has not been made for sexual differences, which are important, and which have been studied in *Hemiaster cavernosus* living in the Seas of Kerguelen, by Sir Wyville Thomson ('Challenger, Atlantic,' vol. ii, p. 229), and by Dr. Theoph. Studer ("Ueber Geschlechts Dimorphismus bei Echinodermen," 'Zool. Anzeiger,' Nos. 67 and 68, 1880). The beds in the North of Africa are certainly far from being exhausted, and the Tertiary strata yet unexplored doubtless contain many Echinides which by-and-by will become known. Mr. Etheridge has described a new Scutelloid genus obtained from the Miocene of Morocco (83), the genus *Rotuloidea*. The Tertiary deposits of Egypt contain numerous species of Echinides, of which some only have been described, and for the most part very imperfectly; they have

been studied more completely of late years. Prof. Fraas has given an account of many Nummulitic species (84), and has discovered the large Clypeaster of the Pyramids (*Clypeaster Ægyptiacus*, Wright), from a Miocene rock. I have since published a 'Monograph of the Nummulitic Echinides of Egypt' (85), in which forty-four species are figured and described, and in another Monograph (86) the Eocene Echinides of Egypt and of Lybia, brought by Professor Zittel from his voyage of discovery with Dr. Rohlfs, the new species are added by me to that interesting Echinitic fauna. I may remark *en passant* that I have given in these monographs figures of the masticating apparatus of *Conoclypeus conoideus* which Dr. Zittel had already discovered. This genus ought, therefore, to be removed from the family of the CASSIDULIDÆ, in which it has hitherto been classed.

Our knowledge of the fossil Echinides of Asia is not yet very extensive. Since the 'Monograph on the Nummulitic Beds of India,' by MM. d'Archiac and J. Haime, the only extended memoir which has been published on the subject, to my knowledge at least, is that of M. Stolitzka (87), on the 'Echinoderms of the Cretaceous Formations of India,' in which thirty-eight species are figured and described. Some isolated documents may still be noticed. Prof. Duncan has enumerated eleven Cretaceous species collected in the South-east of Arabia, and at Bagh on the Nerbudda (88). He has likewise given indications of the Cretaceous Echinides of Sinai (89). M. Cotteau, in a notice on the Echinides collected in Syria by M. L. Lartet, has described some new species. Prof. Fraas (91), in his recent travels in Lebanon, has satisfactorily proved that the spines so long known under the name of *Cidaris glandifera*, and believed to be identical with those from the Sequanian stage are, on the contrary, distinct, and are found in Cenomanian beds. M. Fuchs, lastly, has made known some Echinides from the Miocene beds of Persia (92).

In the Island of Borneo Nummulitic beds are found containing Echinides, of which M. Fritsch has described some, establishing the genus *Verbeekia*, still very imperfectly characterised (93).

Thanks to Professor Zittel we know some Echinides from the Tertiary strata of New Zealand (94).

Many recent works, have had for their object the Echinides from the Tertiary strata of Australia; whence new species have been described by M. Laube (95), Mr. Etheridge (96), and Prof. Duncan (97), who has given a list of the species from the Tertiary strata of Australia actually known. They are to the number of twenty-four, and embrace two new genera, *Paradoxechinus*, Laube, and *Megalaster*, Duncan.

It now remains for us to cross the Pacific to California, where we shall have to remark upon some very curious Miocene and Pliocene species of Echinides, discovered by Mr. Remond (98), and figured anew by Dr. Gabb (99). Some new species are still to be indicated from the Eocene of South Carolina, by M. Conrad. Beyond this I have only been able to discover a few isolated notices upon the Secondary and Tertiary

Echinides of the United States in the works published during the last twenty years. On the other hand, assisted by the activity of my learned friend M. Cotteau, whose name I have had to mention in connection with the Echinitic faunas of almost every region, the fossil Echinides of the Antilles are now very well known. Mr. Guppy had already published nine new species from the Tertiary formations of the Island of Anguilla. M. Cotteau (102) has added as many as twenty-six Eocene and Miocene forms. He has made known the magnificent species of the genus *Asterostoma* (103), of which we had known only up to the present the single individual type, coming from the Tertiary strata of the Island of Cuba, where it is accompanied with some other species, which will be figured afterwards.

In South America the Echinitic works within my knowledge are the isolated descriptions of some new species. Philippi (104) has described some from Bolivia; Herr Steinmann (105) has just added two others; and I have described one from Ecuador (106).

To this rapid exposé of the progress of our knowledge of the fossil Echinides during the last twenty years, it will not be out of place to add a few words on the recent discoveries which have been made among living Echinides in the existing seas. It does not, however, appear necessary to enter into much detail or to do more than mention the published works. The magnificent and excellent work of Alexander Agassiz (107), 'Revision of the Echini,' published between 1872 and 1874, faithfully resumes all the works anterior to it, and, so to speak, fixes our ideas upon the species of Echinides known up to this time in our seas. It will always serve as a *point de depart* for all future works. The number of distinct species which are there found established and described amounts to 206. Since then the number has been considerably augmented, but always and almost solely by the recent Expeditions undertaken for the exploration of the bed of the sea, aided by dredges and appropriate machinery placed at the command of the explorers. Most of the new types which have been discovered belong to the most extraordinary forms; and some of these represent genera found hitherto only in a fossil state, connecting in a very remarkable manner the existing fauna with that of former times. Already in the Dredging Expedition of the "Porcupine," Wyville Thomson had observed in the living state and made known in a complete manner the *Asthenosoma* (109), those regular Urchins so curious with a flexible test composed of imbricated plates, reminding us of certain Palæozoic genera and belonging to a family, the ECHINOTHURIDÆ, represented up to the present time by some fragments found in the Upper Chalk and a single example of a recent species from an uncertain province. We know actually that it was one of two species all living in depths from 10 to 2,750 fathoms, but principally in the greatest depths. The appearance of the first species of *Pourtalesia*, dredged by François de Pourtales in the latitude of the Antilles, had astonished all the Echinologists. This extraordinary genus, bordering on the *Holaster* and almost on the *Infulaster*, approached more particularly the Urchins of the

White Chalk. We have lately discovered that there are several species, most of them bizarres forms; and the Expedition of the "Challenger" has made known many new genera, which are connected with it, so that now this species, known at first by a single example, has become the *point de depart*, a few years after its discovery, of a family which appears to be truly limited to great depths. These two examples will suffice perhaps to make us appreciate the development of our knowledge of the Echinides of the actual seas during the last eight years.

I do not intend to enlarge here upon the new species and the new genera which have been successively brought to light by the dredging expeditions of the "Porcupine," of the "Hasler" (110), of the "Josephine," of the "Blake" (111), of the "Challenger" (112). This last, which perhaps may be considered the most fruitful, has brought to our knowledge no less than forty-four new species and sixteen new genera. We are able to estimate roundly at 300 the number of the species which we know in our actual seas, and it is not only the discovery of new types which we owe to these expeditions, so rich in results of all kinds, but numerous and valuable indications and information on the geographical distribution of species, and on their vast bathymetrical limits, which are of the greatest utility in explaining certain facts relative to the distribution of fossil species, a subject upon which, perhaps, we may have experienced embarrassment. Now that we know that the *Spatangus Rashi* is found from the Hebrides to the Cape of Good Hope, that the *Brissopsis lyrifera* and the *Schizaster fragilis* are met with both in the seas of Norway and in the south of the Indian Ocean, and that certain species of *Cidaris* descend from the shore to 2000 fathoms, and that a *Phormosoma* descends from 200 to 2700 fathoms, many facts relating to fossil Echinides will perhaps be able to find an interpretation.

This is not the place to recapitulate the progress of the state of our knowledge upon the Morphology, the Anatomy, and the Embryogeny of the Echinides; moreover, I am not competent to undertake the work.

I desire only to mention a remarkable work by M. Lovén (113), 'Études sur les Échinides,' accompanied by fifty-three excellent plates which contain very curious and most interesting researches on the structure of the solid skeleton of Urchins, and on the different points in their organisation. This useful work ought to be studied by all those who wish to make the Echinides the object of serious research.

My task is now brought to a termination. I hope that those who, in the next twenty years, undertake a similar work will be able to register as many new facts, as many new discoveries, and as much progress of all kinds in the study of this very interesting group of animals, of which I have endeavoured to give a *résumé* in the following summary Table, which is probably less complete than I wished it to be.

Appendix containing a List of the Works referred to in the Text. See Page v.

1. Walter Keeping, 1878. On Pelanechinus (Quart. Journ. Geol. Soc., vol. xxxiv).
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7. Cotteau, 1865. Notes sur les Oursins crétacés des Martigues (Bull. Soc. Géol. de France, 2e Série, T. 21).
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11. Cotteau, 1869. Descr. de quelques Échinides Tertiaires des environs de Bordeaux (Actes de la Soc. Linnéenne de Bordeaux, T. 27).
12. Cotteau, 1877. Descr. des Échinides de la Colonie du Garumnien de la Haute Garonne (Annales des Sciences Géologiques, T. 9).
13. Cotteau, 1877. Description des Échinides Tertiaires de la Corse, in Descr. de la Faune des Terrains Tertiaires Moyens de la Corse, par A. Locard.
14. Cotteau, 1877. Catalogue des Échinides jurassiques de Normandie (avec 2 planches), Mémoires de la Soc. géologique de Normandie.
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A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART FIRST.

ON THE CIDARIDÆ.

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A MONOGRAPH

ON THE

CRETACEOUS ECHINODERMATA.

ON THE CRETACEOUS GROUP.

The Cretaceous group, as a whole, as developed in England, has been so fully described by Conybeare and Phillips,[1] and its subdivisions by other authors,[2] that it appears to be unnecessary to devote any great space to this branch of the subject, beyond an epitomized outline of the subdivisions of the Cretaceous rocks, with brief notes on the species of *Echinidæ* found therein, and the co-relation of these stages with their equivalent zones of life in the Cretaceous systems of the Continent of Europe; and as the Isle of Wight exhibits some of the best coast-sections of the Cretaceous rocks in the British

[1] The 'Outlines of the Geology of England and Wales' contains a most able account of this formation.

[2] The following, among many others, may be consulted for important information on the Cretaceous formation:—Dr. Fitton's various memoirs in the 'Geol. Transactions,' and 'Quarterly Journal of the Geol. Soc.;' Sir H. De La Beche, "On the Chalk and Greensand of Lyme Regis," 'Geol. Trans.,' vol. ii; Young and Bird and Professor John Phillips on the Geology of Yorkshire; Dr. Mantell's works on the Geology of Sussex; Samuel Woodward's 'Geology of Norfolk;' Dixon's 'Geology of Sussex.' The various memoirs in the 'Quarterly Journal of the Geol. Soc.' on the Cretaceous Rocks, by Professor E. Forbes, Messrs. Lonsdale, Rose, Austen, Cunnington, Morris, Weaver, Rose, Clarke, Bunbury, Bowerbank, R. C. Taylor, Ibbetson, Toulmin Smith, D. Sharpe. The Manuals of Geology, by Sir H. De La Beche, Sir Charles Lyell, and Professor Jukes; and the "Geology of the Isle of Wight," by Mr. H. W. Bristow, in the 'Memoirs of the Geological Survey.' The reader will likewise find most valuable information in Le Vicomte D'Archiac's 'Histoire des Progrès de la Géologie,' tom. iv and v, "Sur la Formation Crétacée;" the memoirs by M. E. Guéranger, in the 'Bull. Soc. Géol. de France;' M. Cornuel's "Section of the Environs of Vassy" ('Mém. Soc. Géol. de France,' t. iv); M. Leymerie's "Memoir on the Department of the Aube" ('Mém. Soc. Géol. de France,' t. iv and v); and in the different important works by the late M. Alcide d'Orbigny.

Islands, in their stratigraphical order of superposition, I shall take these as a type of the whole, supplying any deficiency in the series by examples afforded by other localities.

THE LOWER GREENSAND.

The Lower Greensand, occupies an extensive tract in the southern part of the Isle of Wight, where it attains a thickness of nearly 900 feet; this great formation has been so carefully examined and well described by the late Dr. Fitton,[1] in his stratigraphical account of the section from Atherfield to Rocken End, on the south-west coast of the island, that I must refer the reader for full information to that valuable memoir for further details. Having worked several times over all the beds of that remarkable and most instructive district, and in my excursions had the advantage of the local knowledge and assistance of Dr. Fitton's collector and guide,[2] I shall now merely attempt a generalized account of this section, for the purpose of pointing out the beds with which we are more immediately interested, in our description of the Echinidæ contained therein.

The entire series of the Lower Greensand beds, 809 feet in thickness, rise in succession from the shore and ascend into the cliffs between Atherfield Point and Rocken End, towards which they dip at an inclination of about 2°.

The following Subdivision of the Atherfield Section was proposed by Dr. Fitton, in ascending order.

	Feet.	Inches.
I. Perna Mulleti Bed	5	3
II. Atherfield Clay	60	0
III. The Cracker Rocks	85	0
IV. The Lower Gryphæa Group	32	0
V. Scaphites Group	50	4
VI. Lower Crioceras Group	16	3
VII. Walpen Clays and Sands	57	0
VIII. Upper Crioceras Group	46	2
IX. Walpen and Ladder Sands	42	0
X. Upper Gryphæa Group	16	0
XI. Cliff-End Sands	20	0
XII. Foliated Clay and Sand	25	0
XIII. Sands of Walpen and Black-Gang Undercliff	97	0
XIV. Ferruginous Sands of Black-Gang Chine	20	6
XV. Upper Clays and Sand-Rock	118	0
XVI. Various Sands and Clays	118	4
	808	10

[1] "A Stratigraphical Account of the Section from Atherfield to Rocken End, in the South-west Coast of the Isle of Wight," 'Jour. of the Geol. Soc.' vol. iii, p. 289, 1847.

[2] Mr. Charles Wheeler, fisherman, at Ventnor, is the person alluded to, he has a most correct knowledge of the range and position of all the beds, and of their fossil contents, and is a most trustworthy guide to the Atherfield Section.

I. *The Perna beds*, which here form the base of the Lower Greensand, rest upon Weald clay; the junction between the lacustrine series of the latter with the marine deposits of the former exhibit no trace of disturbance; a thin seam of bone-bed, composed of the teeth of fish of lacustrine species, attest a change of conditions similar to that observed in some junction-beds in other formations, as between the Upper Keuper and the Lias, and the Upper Silurian and Devonian series. This junction, which is only sometimes visible, occupies about eight inches of vertical thickness; on one occasion I succeeded in detaching a block of rock, about a foot thick, from the beds, the lower half of which contained the lacustrine shells of the Weald clay, whilst in the upper half *Perna Mulleti*, Desh., *Exogyra sinuata*, Sow., and other Lower Greensand shells, were found. The Perna beds rise from the base of the cliff, at a point a few yards to the east of the flag-staff of the coastguard-station; they consist of dark-blue sandy clay and greenish sand, forming in parts a very hard rock, and characterized by that remarkable shell *Perna Mulleti*, Desh., which is not found in any other bed in the section. Nearly one hundred species of marine shells are found in the Perna beds; among these *Nautilus Requinianus*, d'Orb., and *Exogyra sinuata*, Sow., appear for the first time, of very large size, and *Hemipneustes Fittonii*, Forb., among the Echinida, with the remains of fish belonging to the genera *Lamna*, *Odontaspis*, *Saurocephalus*, *Hybodus*, &c.

II. *The Atherfield Clay* is of a drab colour, passing into bluish-gray, and contains flat nodular masses. *Ammonites Deshayesii*, Leym., *Pinna Robinaldina*, d'Orb., and several other species of Conchifera, with the bones of a Turtle, and the remains of Echinidæ, are found in this bed.

III. *The Crackers*, so called from the noise produced by the waves dashing over the ledges formed by these rocks on the shore, are the most interesting fossiliferous group of the entire series, and consist of alternations of sandy clays and clays, and two layers of ferruginous sandy nodules. All the clays resemble Fullers' earth, and the sand between the nodular concretions in the lower bed is sometimes indurated into an imperfect stone. The lower part of this group is a brown clay and sand, called the Lower Lobster bed, from the number of *Astacus Vectensis*, Bell, found therein; the succeeding beds are sands, containing concretionary masses of sandstone full of beautiful fossil shells, *Ammonites Deshayesii*, Leym., *Pholadomya Martini*, Forb., *Myacites plicata*, Sow., *Corbula striatula*, Sow., and several other Conchifera. Many of the *Myadæ* are found in the upright position they assumed during life. The lower sandstone, from a foot to eighteen inches in thickness, is almost entirely made up of *Gervillia aviculoides*, Sow., *Trigonia Dædalæa*, Park., *Ammonites Deshayesii*, Leym., and other shells. The upper layer of sandstone contains coniferous wood and a *Teredo*, and the upper clays are fossiliferous throughout. In the concretionary nodules of the lower series of this group I have collected *Pseudodiadema Autissodorense*, Cott., *P. Ibbetsoni*, Forb., and *Hemipneustes Fittoni*, Forb., with the

beautiful winged shells *Rostellaria glabra*, Forb., *R. retusa*, Sow., *Pterocera Fittoni*, Forb., and several species of Cerithia, as *Cerithium turriculatum*, Forb., *C. Neocomiense*, d'Orb., and *C. Phillipsi*, Leym.

IV. *The Lower Gryphæa* or *Exogyra Group* has for its base a thick bed of ferruginous sand, overlain by sand containing *Perna alæformis*, Sow., and *Terebratula sella*, Sow., in great abundance, in thin seams of sand. The zones with *Exogyra sinuata*, Sow., which here are very large, are found in the upper part of the group.

V. *The Scaphites Group* forms three beds; the lowest is composed of brown ferruginous sand, containing *Exogyra sinuata*, Sow., *Terebratula sella*, Sow., *Rhynchonella Gibbsiana*, Sow.; and of the Echinidæ I found *Cardiaster Benstedi*, Forb., and *Nucleolites Olfersii*, Ag.; the middle beds, about two feet in thickness, contain layers of nodules enclosing *Scaphites gigas*, Sow., and *Scaphites Hillsii*, Sow.; the upper consist of thick beds of greenish sand, containing, in the upper part, fine large specimens of *Exogyra sinuata*, Sow.

VI. *The Lower Crioceras Group* consists of ranges of large sandy nodules, enclosing *Crioceras Bowerbankii*, Sow.; the lowest range rises on the west of Whale Chine, and is succeeded by two other ranges, all three enclosed in sand about nine feet thick; the lowest, furnishing the best fossils, passes the bottom of Whale Chine, from whence I have obtained several large specimens.

VII. *The Walpen and Ladder Sands and Clay* extend from the east of Walpen to half way between Ladder and Whale Chines, where they are well seen; the lower half of this group contains *Ammonites Martini*, d'Orb., and a large *Gryphæa;* the upper half, which is clayey below and sandy above, contains *Dentalium*, *Myacites mandibula*, Sow., *Pinna Robinaldina*, d'Orb.

VIII. *The Upper Crioceras Group* consists of sandy nodules imbedded in sand, and contains *Crioceras Bowerbankii*, Sow., *Ammonites Martini*, d'Orb., *Gervillia solenoides*, Defr., *Terebratula sella*, Sow., and several other shells. This group is seen for some distance along the shore east of Walpen Chine, which is crossed by it, as are also Ladder and Whale Chines.

IX. *The Walpen and Ladder Sands* consist of greenish and gray sand, with a layer of large fossiliferous nodules at the base, containing *Serpulæ*, *Thetis*, *Gervillia*, *Cucullæa*, *Corbula*, and other shells, together with an Urchin belonging to the genus *Brissus*.

X. *The Second Gryphæa or Exogyra Group.*—The lower part of this group consists of

sand and clay containing small nodules enclosing a *Brissus*, *Ammonites Martini*, d'Orb., and detached valves of *Exogyra sinuata*; above are three or four ranges of *Exogyra sinuata*, Sow.; the parallel edges of these large shells, as seen in the cliff, indicate three or four continuous strata, with irregular clusters between them. The second or upper Gryphæa group appears at low water at Shanklin, where the several ranges of *Exogyræ* are seen rising beneath each other. Varieties of this shell appear to me to characterize different beds; for example, the specimens of *Exogyræ* from the Crackers and Lower Gryphæa group present marked differences when compared with shells of the same species from the Upper Gryphæa group. A similar observation has been made by M. Cornuel on the *Exogyræ* collected by him near Vassy, in France. This geologist assured Dr. Fitton "that he could at once assign each variety of form to a special place in the section of that vicinity." Small fragments of vegetable remains (*Lonchopteris Mantellii*, Brong.) occur not only in these beds, but nearly throughout the entire formation.

XI. *The Cliff-End Sands* consist of uniform sand about fourteen feet thick, with a subordinate bed of fossiliferous clay containing *Trigonia Dædalæa*, Park., in the lower part, and plant-like pyritiferous concretions in sand and clay in the upper part.

XII. *Foliated Clay and Sand.*—Consist of alternations of dark-blue clay and greenish, translucent, siliceous sand, containing nodules of pyrites and large irregular masses of coarse sandstone. These beds are well seen in Walpen and Black-Gang Chines, but no fossils have hitherto been found in them.

XIII. *Sands of Walpen and Black-Gang Undercliff.*—This group commences with a bed, about ten feet in thickness, of loose white sand, with thin laminæ of gray clay; this is succeeded by seventy feet of greenish and brownish sand overlain by seven feet of coarse ferruginous sand, with rounded grains of iron-ore in the lower half of the bed, and by twelve feet of alternating sand and clay, making a total of 100 feet. There are only very few fossils in this group—*Myacites plicata*, Sow., and *M. mandibulata*, Sow.

XIV. *The Ferruginous Bands of Black-Gang Chine* rise from the shore between Rocken End and Black-Gang Chine, and form the uppermost fossiliferous group of the Lower Greensand; they are composed of brown and yellow sand, with layers of ferruginous concretions, overlain by a bed of ferruginous sandstone, about five feet in thickness; the group is about twenty feet in all, and is the equivalent of the zone of Lower Greensand at Parham Park, and other places in Sussex, and near Sandgate in Kent. The sands in this group are fossiliferous throughout, and the species identical with those found in the Perna bed and Cracker rocks at the bottom of the section.

XV. *The Upper Clays and Sand Rock* consist of forty feet of dark clay with pyrites, separated by eighteen feet of white and green-coloured sand from a mass of clays and sands sixty feet thick. The bed 47 of this group is dug near Rocken End for the manufacture of glass; it contains no fossils.

XVI. *Various Sands and Clay* constitute the remainder of the section; they measure about 120 feet in thickness, and are overlain by the Gault.

The Lower Greensand represents the upper portion of the rocks known as the *Terrain Néocomien* of MM. Thurmann and d'Orbigny; *Terrain Jurassique supérieur* of M. Mathéron; *Couches adossées au Jura* of Von Buch; *Formation Waldienne et Néocomienne* of MM. Dufrénoy and Élie de Beaumont; *Calcaire à Spatangues, L'Argile ostréene*, of M. Cornuel; *Argiles tégulines et grès vert* and "*Terrain Néocomien*" (Wealden) of M. Leymerie. The French geologists consider the Wealden clay and Hastings sand as the inferior, and the Lower Greensand the superior, portion of their *Néocomien*, whilst English geologists describe the Wealden and Lower Greensand as distinct formations.

THE GAULT.

In several coast-sections the Gault is seen separating the Lower from the Upper Greensand; this bed of dark clay is called "the blue slipper," from the tendency of the overlying strata to form landslips by gliding over its surface. The charming scenery of the Undercliff has been in a great measure produced by the foundering of the Upper Greensand and Cretaceous rocks over the Gault clay; the rain-water having saturated these porous beds, bursts forth in springs, which wet the surface of the clay, and occasions slips of the superincumbent strata. A rich fertile soil is thus formed upon a broad terrace of stiff clay, exposed to the south, and sheltered from the north by a high mural escarpment of Upper Greensand. Under these favourable physical conditions vegetation springs up in great luxuriance, on a natural terrace high above the sea, producing a coast-scene unequalled in beauty in the British Isles.

The Gault is about 100 feet in thickness, and in the Isle of Wight contains few fossils, as *Inoceramus sulcatus*, Sow., and *I. concentricus*, Sow.; near Folkstone and Charmouth it has yielded many beautiful shells in high preservation. I shall figure some rare *Echinidæ* from this bed at Folkstone.

The Red Chalk is a remarkable stratum, supposed to be the equivalent of the Gault; it is limited both in thickness and extent, for if we take, says the Rev. T. Wiltshire, one hundred feet as its maximum and four feet as its minimum thickness, and 100 miles as its extreme length, we shall not be far from the truth. It is said to be peculiar to the English Chalk. It is well exposed at Speeton, near Filey, on the Yorkshire coast, and at Hunstanton Cliff, near Lynn, Norfolk; in both localities it is a red calcareous rock, deeply coloured by

the peroxide of iron, and containing minute siliceous grains, and small pebbles of chalcedony, quartz, flint, &c. This rock from Hunstanton yielded by analysis carbonate of lime, with a little alumina, 82·3; peroxide of iron, 6·4; silica, 11·3 = ; 100.

Hunstanton Cliff,[1] of which the annexed woodcut gives an idea, consists of five different beds—1st, the uppermost, or white chalk, is forty feet thick; 2nd, bright-red chalk, four feet; 3rd, yellow sandy bed, ten feet; 4th, a dark brown pebbly stratum, forty feet; and 5th, a dark-coloured bed, almost black, twenty feet.

These divisions at Hunstanton, the Rev. T. Wiltshire states, do not run into each other, but are quite distinct; the red chalk is as clearly separated from the white as though the one had been covered by a broad band of paint, and the same remark holds true of the others. When the sun shines upon the cliff, and lights up the bright white, bright red, the pale yellow, and the dark brown and black, and casts a shadow over the mass of gaily tinted materials at the base, a picture is produced not easy to be surpassed in beauty, and certainly not to be fully appreciated unless it is seen.

The Red Chalk is very fossiliferous, containing Ammonites, Belemnites, Brachiopoda, Echinidæ, and Corals.

In compliance with my request, my friend the Rev. T. Wiltshire, F.G.S. has kindly sent me the following note, embodying his latest observations on the Red Chalk at Speeton.[2]

"In answer to your inquiry respecting the natural section of the Red Chalk at the

[1] For ample details, see the Rev. Thos. Wiltshire, on the 'Red Chalk of England.'

[2] To this gentleman's kindness I am likewise indebted for the above woodcut, copied from a water-colour drawing in his collection.

most northern extremity of that bed in England, viz., in the neighbourhood of the little Yorkshire village of Speeton, I send you a few scanty notes. On my first visit to Speeton, some years since, I imagined, as I subsequently described in the second volume of the 'Geologist Magazine,' and in the 'Proceedings of the Geologists' Association' for 1859, that the Red Chalk in Yorkshire consists of a couple of bands of a highly coloured marl, of about thirty feet in thickness from top to bottom, and that its fossils are of such forms as to imply a close relationship with Gault species. This opinion I derived from seeing the section in a gulley to the east of the village; but subsequent investigations made upon the shore under the cliff, at a mile or more from the ravine, showed me that my former observations were slightly incorrect, and that the Red Chalk, in that part of Yorkshire at least, contains two more additional coloured bands, and that its total thickness from top to bottom is not less than 100 feet, and that its upper portion belongs to the Lower Chalk series.

"The highest bed of Red Chalk at Speeton may be seen rising from the beach at a very gentle inclination, at about a mile and a half to the south-east of the gulley. This bed, which is of varying thickness throughout its course, may be estimated as being on an average about five feet thick; it is of a pale pink colour, very hard, and presents a strongly marked appearance from the white chalk, above and below, with which it is in contact. The fossils found in it are *Rhynchonella Mantelliana*, *Gryphæa vesicularis*, *Discoidea cylindrica*, *Holaster subglobosus*, *Spines of Cidaris*, *Spines of Diadema* small vertebræ and teeth, together with a considerable number of *Terebratulinæ graciles*. Above this bed, in the white chalk, are found *Holaster subglobosus* and *Ammonites peramplus*. The pink band just mentioned is followed by a greenish-yellow chalk, about forty feet thick, almost destitute of organic remains, except fragments of *Inocerami*, and marked by numerous thin layers of marl, not unlike those met with in the Lower Chalk of Sussex. The next bed in descending order is one of a light pink colour, about three feet in thickness, likewise destitute of fossils, with the exception of fragments of *Inocerami*. This is followed by another stratum of greenish-yellow chalk, about nine feet thick, containing small *Gryphææ*, and *Terebratulæ semiglobosæ*, and *Peltastes*, but, like the two preceding beds, generally unfossiliferous. The greenish-yellow chalk is succeeded by five feet of white and red chalk, in thin bands, very deficient in organic remains, and this rests upon a pale-red band, about seven feet thick. In the upper part of this last seven feet of red material are many *Vermiculariæ umbonatæ*, and in its lower portion many small *Terebratulæ* and *Inocerami*. About ten feet of greenish-white chalk, somewhat hard, is the next bed, in which few fossils are to be noted except a Terebratula and a bone or two of a Star-fish. In all these strata enumerated there is a marked absence of Belemnites, but in the succeeding and last bed, one of a bright-red colour, and more than thirty feet thick, they become exceedingly abundant. This red band is the one from which most of the Red Chalk fossils from Speeton are derived; it is exceedingly fossiliferous. In its uppermost portion very large *Terebratulæ* may be obtained, and generally many of an ordinary size; at about twenty feet below its commencement, *Belemnites*, *Pentacrini*,

and spines of a Cidaris occur, which appear to be distinct from the Cidaris spines, ninety-four feet above, in the pink band. There are, moreover, no traces of *Holaster subglobosus* nor *Discoidea cylindrica* in this bright-red bed; and Ammonites cannot be seen, though so numerous in the Speeton Clay, upon which it rests. This red band gradually becomes nodular, and of a bluish cast, and gradually merges into the Speeton Clay.

"Inland the Yorkshire beds put on a somewhat different appearance, for on the escarpment of the Wolds, as at Great Givendale, the beds of Red Chalk abound in pebbles and in *Terebratulæ biplicatæ*, a feature that is absent at Speeton, though conspicuous at Hunstanton, in Norfolk.

"A careful inspection of the fossils derived from the Red Chalk series of Yorkshire and Norfolk shows that the two extremities of the bed are very distinct in character, and have not much in common, and that the southern stratum is a more littoral deposit than the northern."

My friend John Leckenby, Esq., F.G.S., of Scarborough, having studied critically the fossils of the Speeton Clay, has kindly supplied the following note on that formation, from which it appears that until now the true relations of this deposit have not been clearly understood.

"The Speeton Clay of Yorkshire, besides many minor subdivisions, presents two important and well-marked sections; well-marked lithologically, still more so by their fossils. The line of separation midway, or nearly so in the series, is also distinct and clear, with no passage-beds indicating a transition from one set of conditions to another. Its entire thickness cannot be less than 400 feet, but in consequence of the denudation of the inclined edges of its beds it nowhere presents a continuous section of more than 150 feet.

"The lower division is characterized in its upper beds by Ammonites and Gasteropods, which I at one time felt inclined to refer to the Oxfordian system, and many palæontologists yet contend that the thick coronated Ammonites which here abound belong to the Oxfordian group. Without, however, doing violence to our preconceptions of stratigraphical relations, we shall find that they approach much more nearly to Portlandian types, as figured by d'Orbigny; and *Am. Gravesianus* cannot be distinguished from a common, but unpublished form, in the Speeton Clay. In the lowest beds of this lower division are found *Am. triplicatus*, *Am. excavatus* (var. *alternatus*, Von Buch), with univalve and bivalve shells identical with species which I have obtained from the Kimmeridge Clay of Lincolnshire, in a railway-cutting near Brigg. The line of demarcation before referred to is characterized by a thickish band of pseudo-coprolites, and by many remains of Saurian animals; it would appear that here there has been a period of repose, during which the Saurian dwellers upon a shallow reef disported themselves, and that we have a well-marked division between the close of the Jurassic and the commencement of the Cretaceous period. A large and almost perfect example was lately procured and is now in the possession of Right Hon. Lord Londesborough, the lord of the manor of Speeton.

"The habit of referring the whole of the Speeton Clay of Yorkshire to the Cretaceous period, in deference to established authorities, has hitherto prevented a clear reading of

the evidence furnished by its fossils, and from the fact of so many of its Ammonites of the Oolitic type being found, not *in situ*, but in boulders, has led to the inference of the existence, at some remote period, in Filey Bay, of great beds of Oxford Clay similar in character to the Oxford Clay of the south of England.

"The Ammonites can, however, with much more propriety, be referred to Portlandian types, and the wasted beds which have furnished the boulders doubtless pertain to the same epoch.

"Above the line of Saurian remains alluded to, all the fossils belong to the Cretaceous type; and amongst the exact representations of a Neocomian fauna many others are found which in general features closely resemble them. Amongst the former, *Ammonites Deshayesii*, Leym., and *Vermicularia Sowerbii* may be mentioned, while *Crioceras Beanii*, Phil., cannot easily be distinguished, if at all, from *C. Cornuelianum*, d'Orb.

"If we seek for the equivalents of the Upper Greensand in the Speeton Clay, we must do so rather in the lower beds of Red Chalk which overlie that deposit than in the clay itself; and the frequent presence therein of *Inoceramus Coquandianus*, d'Orb., favours this view.

"The junction of the lowest beds of Speeton Clay with the Coralline Oolite cannot be traced along the coast, but may be seen at some distance inland, near the village of Grimston, one of the stations on the line of railway between Malton and Driffield."

The Gault is the equivalent of the *Étage Albien* of d'Orbigny, and the *Gault* of the Germans.

THE UPPER GREENSAND.

This formation forms an important feature in the physical geology of the Isle of Wight; in Compton and Sandown Bays it is seen in its relative position to the Lower Greensand below and the Chalk above, and in the Undercliff it forms a bold, mural, light-coloured escarpment, with rugged lines of cherty beds, producing a fine effect above the rich foliage which clothes the undercliff. According to H. W. Bristow,[1] Esq., F.G.S., the Upper Greensand under St. Catherine's Down is about 155 feet thick; the lower fifty-five feet consist of "bluish, sandy, micaceous beds, throwing out water at their junction with the Gault, and passing upwards into yellowish-gray sand, also micaceous, with sandstone and some chert, forty feet thick. Sandstone and chert imbedded in sand make up the greater part of the rest of the section, the middle portion of which is mostly blue chert based upon seven feet of sandstone, inclosing a bed of freestone four feet thick, whilst the uppermost fifteen or twenty feet consist of calcareous sandstone, forming a vertical face at the summit of the cliff."

In the island the remains of Echinidæ are not abundant in these beds; the Upper Greensand, near Warminster and Devizes (Wilts); Blackdown (Devon); and near Charmouth (Dorset), and Cambridge, are the best localities for the fossil Echinodermata of this formation.

[1] "Memoirs of the Geological Survey," the 'Geology of the Isle of Wight,' p. 24.

CHLORITIC MARL.

At the base of the Chalk, and dividing that formation from the Upper Greensand, is a remarkable fossiliferous bed, full of green specks of silicate of iron, and called, in consequence, Chloritic Marl, which at St. Catherine's Down measures five feet in thickness. This Marl is characterized by a suite of fossils, some of which, as *Scaphites æqualis*, Sow., here appear for the first time, and seem to be special to the bed; with these are found *Ammonites varians*, Sow., *Amm. splendens*, Sow.; several PROTOZOA belonging to the genera *Spongia*, *Siphonia*, and *Scyphia*; ECHINODERMATA, as *Ananchytes lævis*, Deluc; *Catopygus carinatus*, Goldf.; and *Discoidea subuculus*, Leske; together with several species of MOLLUSCA. The same stratum occurs near Chardstock, from whence I have obtained many fine specimens of *Pseudodiadema tumidum*, Forbes, *P. subnudum*, Ag., *Pedinopsis*, *Holectypus*, and several other species, most of which are common to this rock and the Upper Greensand, of which it probably forms the uppermost bed.

The Upper Greensand appears to correspond to the *Glauconie crayeuse* of the French, the *Tourtia* of the Belgians, the *Grünsand* of the Germans, and the *Étage Cénomanien* of d'Orbigny.

THE LOWER CHALK, AND CHALK-MARL.

The Chalk formation occupies a large area in the Isle of Wight, and in the southern and eastern parts of England. It consists of nearly pure carbonate of lime, and in many cases is almost entirely composed of microscopic shells, either fractured or entire. My friend H. C. Sorby, Esq., F.G.S., by preparing thin slices of chalk on slides of glass for microscopic examination, has shown that many beds of that rock consist of from 90 to 95 per cent. of the cases of *Foraminifera*, and of comminuted shells. The chief difference between the Upper or soft white Chalk, and the Lower or hard Chalk is caused by the filling up of the cavities of the shells by calcite or crystalline carbonate of lime, where it has probably been deposited by infiltrating water, which has carried away some of the lime in percolating through the higher beds. The Chalk formation is divided into Chalk-marl at the base, Lower or hard Chalk without flints, and soft or Upper Chalk with flints. In the Isle of Wight the whole formation is 1300 feet in thickness, whilst in England it varies from 600 to 900 feet.

The Lower Chalk near Dover is of a grayish colour, and much indurated in parts. It is very rich in *Echinidæ*, and contains several new species. Unfortunately, many of the finest specimens are impregnated with iron, and perish by the decomposition of the pyrites. At Lewes, in Sussex, it is a hard, close-grained rock, with an earthy fracture, and contains many urchins in fine preservation.

The following section, by the Rev. W. D. Conybeare, of the Chalk cliffs near Dover,

exhibits so well the position and relation of the Gray Chalk, which contains so many fine Echinidæ, that I have introduced it here for reference. The strata lie in the following descending order, and are collectively about 820 feet thick.

1st. *The Chalk with numerous flints;* it is about 350 feet thick, and may be thus divided:

I. With few organic remains.

II. A bed consisting chiefly of organic remains in which numerous flints of peculiar forms are interspersed; and a few beds of flints run along it.

2nd. *The Chalk with few flints.* This stratum is about 130 feet thick.

3rd. *The Chalk without flints* is 140 feet thick, and consists of—

I. A stratum containing very numerous and thin beds of organic remains, 90 feet thick.

II. A stratum about 50 feet thick, with few organic remains.

4th. *The Gray Chalk.* This is estimated to be not less than 200 feet in thickness, and is that from which has been collected most of the fine specimens of *Cidaris Bowerbankii*, Forb.; *Pseudodiadema ornatum*, Forb.; *P. tumidum*, Forb.; *P. variolare*, Brong.; *P. Brongniarti*, Ag.; *P. Mackiei*, Wowd., *Salenia Austeni*, Forb.; *S. Clarkii*, Forb.; *S. gibba*, Forb.; *S. granulosa*, Forb.; and *S. petalifera*, Defr., with other specimens of Chalk-marl species.

The Lower Chalk and Chalk-marl are represented on the Continent by the *Untere Kreide* and *Pläner* of the Germans, the *Craie tuffeau* of the French; and the *Étage Turonien* of d'Orbigny.

THE WHITE CHALK.

The uppermost portion of the Cretaceous formation extends across the island in an east and west direction, from the Needles to Culver Cliff, and all its beds are fully exposed in several magnificent coast-sections; as these beds are nearly vertical or highly inclined at Alum and Scratchells Bays on the east, and at Culver Cliffs on the west, the subdivisions of the whole Cretaceous formation, and the way the beds pass into each other, may be most satisfactorily ascertained. The bands of flints are well displayed in Scratchells Bay and Culver Cliffs, and there is a fine exposure of vertical Chalk strata in a pit on Brading Down; in all these localities, and many others which it is unnecessary to enumerate, the flints appear as parallel layers at certain intervals in the strata, presenting a striking contrast from their blackness to the snowy aspect of the Chalk with which they are interstratified.

"In consequence of the high angle at which the Chalk dips throughout the greater

part of its range from west to east, the surface occupied by it is very inconsiderable compared with that of most of the other strata above and below it, but its horizontal extension becomes greater in proportion as the inclination of the strata diminishes. For this reason, from Alum Bay to Mottestone Down, and from Carisbrook to Culver Cliff, between which intervals the Chalk is nearly vertical, it constitutes a mere ridge of high land, which is scarcely a quarter of a mile broad in Aston Down; but between Mottestone Down and Carisbrook, where the strata are less inclined, the width of the Chalk exceeds three miles."[1]

"The flints in the Chalk are for the most part irregular in shape, but they sometimes constitute tabular layers coincident with the stratification, or else filling cracks and joints. Those flints which occur parallel with the bedding are of a different age from those filling the cracks and joints. The former are derived from siliceous matter, frequently, and perhaps in most instances, deposited contemporaneously with the calcareous sediment of which the Chalk is composed, around sponges and other organized bodies, the forms and internal structure of which are still preserved. The latter, on the contrary, are of more recent origin, having been carried by percolating water holding silica in solution into cracks and joints formed by the Chalk during or after its solidification. The tabular bands of flint filling cracks and joints are therefore, and as might be expected on the last supposition, unfossiliferous, instead of abounding in fossils, as is the case with the other system of flints." "In the upper part of the Chalk, where the beds are the most highly inclined, the flints, which appear to be whole when viewed *in situ*, are found, on closer examination, to be nearly all broken so that when extracted from the quarry they fall to pieces." "Shattered flints may be observed in the large chalk-pits south of Newport, and on Arreton Down; also on Ashley Down, where the Chalk is rather hard (as is most frequently the case where it is inclined at a high angle), dipping 65° in a direction slightly east of north."[2]

The White Chalk contains many species of Echinidæ, of which the most common are *Echinocorys vulgaris*, Breyn.; *Galerites albo-galerus*, Lamck.; *Micraster cor-anguinum*, Klein; *Cidaris clavigera*, König; *Cidaris sceptrifera*, Mant.; *Cidaris subvesiculosa*, d'Orbigny, and several other forms, to be figured and described in the following pages.

The "Upper White Chalk with flints" of English authors corresponds to the *Craie blanche* of the French, the *Obere Kreide* of the Germans, and the *Étage Sénonien* of d'Orbigny.

Besides the localities already mentioned, it is well exposed and very fossiliferous at Lewisham, Grays, Northfleet, Norwich, Brighton, Dover, and other places in the counties Sussex and Kent, and at Flamborough Head, on the Yorkshire coast.

The following table exhibits at a glance the subdivisions of the Cretaceous formations, with their lithological characters, chief localities, and foreign equivalents, so as to afford an easy reference to the stratigraphical distribution of the species of *Echinidæ* in each of the beds.

[1] Bristow, on the "Geology of the Isle of Wight," 'Mem. of the Geol. Surv.,' p. 28.

[2] Bristow, ibid., p. 31.

A TABLE OF THE CRETACEOUS GROUP OF ENGLAND.

SUBDIVISIONS.	LITHOLOGICAL CHARACTER.	LOCALITIES.	FOREIGN EQUIVALENTS.
THE CRETACEOUS GROUP.			
Upper Chalk	Nearly pure carbonate of lime, with minute fragments of Shells and Foraminifera, forming a white or yellowish-white, soft Chalk; the upper beds of which are interstratified with layers of flints, or tabular layers of dark silex coincident with the stratification.	Isle of Wight, Lewisham, Grays, Northfleet, Norwich, Brighton, Dover, Flamborough Head.	*Craie blanche*, French. *Obere Kreide*, Germans. *Étage Sénonien*, d'Orb.
Lower Chalk, and Chalk-marl.	Hard Chalk, without flints, sometimes passing into Chalk-marl or hard Gray Chalk.	Dover, Folkestone, Lewes (Sussex), Swaffham, Norwich.	*Untere Kreide*, Germans. *Pläner*, Germans. *Craie tuffeau*, French. *Étage Turonien*, d'Orb.
Chloritic Marl ...	Light-coloured marl, full of green specks of silicate of iron, with numerous fossils.	Chard, Chardstock, St. Catherine's Down, Isle of Wight.	*Glauconie crayeuse*, French. *Tourtia*, Belgians. *Grünsand*, Germans. *Étage Cénomanien*, d'Orb.
Upper Greensand .	Siliceous sand, or nearly calcareous sand, with green grains; the rock often contains nodules of chert and masses of limestone.	Warminster, Devizes, Chute Farm, Petersfield, Cambridge, Charmouth, Dorset.	
Gault.....	Dark-blue tenacious clay, sometimes marly, with some concretions.	Isle of Wight, Folkestone, Charmouth.	*Gault*, Germans. *Étage Albien*, d'Orb.
Red Chalk	A thin bed of hard, red Chalk, deeply coloured by the peroxide of iron, and having numerous small siliceous grains and pebbles of quartz, &c., strewed throughout the mass.	Hunstanton Cliff, Norfolk; Filey Bay, Yorkshire.	
Speeton Clay. [Upper part.] ...	A grayish-coloured clay, the upper portion containing Neocomian, the lower portion Portlandian species of fossil shells.	Filey Bay, Yorkshire.	*Terrain Néocomien supérieur* of Swiss and French. *Etage Aptien*, d'Orb.
Lower Greensand .	A great arenacous formation, composed of ferruginous sands with green grains, dark-coloured clays and clayey sands; and in some localities, bands of limestone known as Kentish Rag.	Isle of White, Folkestone, Hythe, Maidstone.	

Classification of the ECHINODERMATA.

The name Echinodermata was given by Klein, in 1734,[1] to the shells of Sea-urchins called Echini. Bruguière[2] subsequently gave the name Echinodermata to that division of the animal kingdom which comprised the Star-fishes and the Sea-urchins. Cuvier[3] included in his class Échinodermes, with *Asterias* and *Echinus*, the *Holothuria*, animals destitute of the prickly skin of the more typical forms, and which had many external affinities with some Mollusca; and subsequently, in his 'Règne Animal,'[4] he grouped in this class *les Échinodermes sans pieds*, forming the order Sipunculida, which connect the Radiata with the Annulose Articulata.

The Echinoderms are highly organized animals, for the most part covered with a coriaceous integument. In several orders it is strengthened with numerous calcareous pieces, which together form a complicated skeleton. The external surface of the skin, in many families, develops spines of various forms, which serve as instruments of defence or locomotion to the creatures possessing them. By far the largest number of these animals have a complicated system of vessels for circulating water through their bodies. These aquiferous canals are intimately connected with the life and motion of the animal; by means of this vascular water-system most of the typical groups erect those remarkable suckers which protrude in rows from different divisions of the body; in the *Echinoidea* they escape through holes in the poriferous zones, and in the *Asteroidea* pass through apertures between the small plates forming the middle of the rays; whilst in the *Sipunculida* these organs are altogether absent.

No class of the animal kingdom more clearly exhibits a gradation of structure than the *Echinodermata*; for, whilst some remain rooted to the sea-bottom, and in this sessile condition resemble the *Polypifera*, others, clothed in prickly armour, and exhibiting the true rayed forms characteristic of the central groups, conduct, through a series of beautiful gradations, to soft elongated organisms, whose outline mimics the *Ascidian Mollusca*, whilst others exhibit the long cylindrical body, annulose condition of the skin, and reptatory habits of the *Apodous Annelida*.

With so fertile a field for investigation, it is not surprising that the minute anatomy of the Echinodermata should have engaged the attention of some of the most distinguished zoologists of our age, and have yielded fruits which the physiologist reckons as amongst the most marvellous contributions to morphological science.

[1] 'Naturalis Dispositio Echinodermatum,' Jacobi Theodori Klein, 1734.

[2] 'Tableau Encyclopédique des trois Règnes de la Nature,' 1791.

[3] 'Tableau Élémentaire de l'Histoire naturelle des Animaux,' 1798.

[4] 'Règne Animal destribue d'après son Organisation,' 1834.

The class Echinodermata is divided into eight orders, which, in descending sequence, may be thus arranged:

1. Sipunculoidea.
2. Holothuroidea.
3. Echinoidea.
4. Asteroidea.
5. Ophiuroidea.
6. Blastoidea.
7. Cystoidea.
8. Crinoidea.

Order I. Sipunculoidea—form the apodal Annulose Echinoderms; they have a long cylindrical body, divided into rings by transverse folds of the integument; they have neither tubular suckers nor calcareous parts developed in their body, nor is it divided into a quinary arrangement of longitudinal lobes; some have horny hooklets like the feet of many Annulosa, which they much resemble; their mouth is provided with a retractile proboscis, and surrounded by small tentacula, differing both in structure and arrangement to the homologous parts in the *Holothuria*. In them the type of *Radiata* vanishes and that of *Annulosa* appears. They are unknown in a fossil state.

Type. *Sipunculus edulis*, Pallas.

Order II. Holothuroidea.—Body in general elongated; skin in general soft and leathery, in a few genera strengthened by calcareous or horny spines. Five avenues of suckers divide the body into as many nearly equal segments; mouth surrounded by plumose tentacula, the numbers of which are usually multiples of five; vent at the opposite extremity of the body; digestive organs consist of a large intestine, which makes several coils in passing through the body; respiration performed by internal ramified tubes, like a miniature tree; locomotion effected by contractions and extensions of the body, and by rows of tubular suckers, similar to those in the Star-fishes and Sea-urchins. The softness of their naked integument prevents their preservation in the stratified rocks.

Type. *Cucumaria frondosa*, Gunner.

Order III. Echinoidea.—Body spheroidal, oval, or depressed, enclosed in a test, composed of twenty columns of calcareous plates, with ten rows of holes for the passage of retractile tubular suckers; the surface of the test is studded with tubercles, which have jointed with them moveable spines, of various sizes and forms in the different families and genera; at the summit of the test is the apical disc, composed of give genital plates, perforated for the passage of the ovarial and seminal tubes, and five ocular plates for lodging the five eyes. The mouth, situated always at the under surface, is in many genera armed with five powerful, complicated jaws and teeth, and in others the peristome is edentulous; the vent occupies various different positions, sometimes within the apical disc and surrounded by its elementary parts, sometimes external to the disc, and at the upper surface, side, or base, the relative position of the vent to the disc affording

an important character for the subdivision of the order into two primary groups. The intestine winds rounds the shell, attached by a mesentery, the surface of which, as well as the membrane lining the shell, is covered with vibratile cilia.

Type. The common Sea-urchin, *Echinus sphæra*, Müller.

The Echinoidea are represented by one family in the Palæozoic rocks, and by numerous families in the Mesozoic and Tertiary groups, several of which characterize these great periods of geological time. They likewise abound in our present seas.

Order iv. Asteroidea.—Body stelliform, depressed, with five or more lobes or hollow arms, forming a continuation thereof, and containing prolongations of the viscera; the mouth is always inferior and central, and the intestine often terminates in a vent opening at the upper surface; in some genera the vent is absent; rows of retractile tubular suckers occupy the ambulacral areas in the centre of the under surface of the rays. Skeleton complicated, composed of numerous solid calcareous pieces, variable as to number, size, and disposition; skin coriaceous, studded with calcareous spines of various forms; a madreporiform plate on the upper surface, near the angle between two rays; eyes placed at the extremity of the rays; reptation performed by tubular suckers.

Type. The common Star-fish, *Uraster rubens*, Linn.

This order is represented in the Silurian rocks by several genera. The Oolitic, Cretaceous, and Tertiary rocks contain many extinct forms. The existing species are very abundant in all our present seas.

Order v. Ophiuroidea.—Body discoidal, distinct, depressed, provided with long, slender arms, in which there is no excavation nor prolongation of the viscera; they are special organs of locomotion, independent of the visceral cavity, and have spines, and membranous tentacula developed from their sides; mouth always below and central, serving at the same time as the vent. Skeleton complicated, composed of calcareous pieces, of which the size and number varies in different genera. Their long, slender rays are supported internally on a framework of central vertebra-like pieces; they form special organs of locomotion, independent of the visceral cavity, and numerous plates and spines are regularly disposed along their sides to assist in reptation.

Type. The common Sand-star, *Ophiura texturata*, Lamarck.

This order is represented by one genus in the Silurian, and several genera are found in the Oolitic, Cretaceous, and Tertiary rocks, as well as in our present seas.

Order vi. Blastoidea.—Body in the form of an oval calyx, composed of solid, calcareous plates, provided with five inter-ambulacra and five ambulacra, the latter united superiorly, striated transversely, and having a deep furrow down the middle; ten ovarial holes, opening into five at the summit, with a central oral aperture, a short, slender stem, and the body destitute of arms.

Type. *Pentremites inflatus*, Sow. Carboniferous Limestone.

The genera are all extinct, and belong to the Palæozoic rocks. One species appertains to the Upper Silurian, six to the Devonian, and twenty-four are special to the Carboniferous rocks.

Order VII. CYSTOIDEA.—Body more or less spherical, supported on a jointed stem; the bursiform calyx is formed of close-fitting polygonal plates, varying in number in the different genera, and investing the surface like a coat of mail, except above, where there are three openings, one for the mouth, one for the vent, and one with a valve for the reproductive organs; the fourth aperture is below, and continuous with the canal in the stem. Some have two or four arms, others are armless; certain forms possess articulated tentacula and curious comb-like appendages, or pectinated rhombs, in connection with the plates.

Type. *Pseudocrinites quadrifasciatus*, Pearce. Upper Silurian.

This order is extinct. All the genera are found in the Silurian and Devonian rocks.

Order VIII. CRINOIDEA.—Body fusiform, distinct, formed of a calyx composed of a definite number of plates, provided with five solid arms, independent of the visceral cavity, and adapted for prehension; mouth and vent distinct; no retractile suckers; ovaries at the base of the arms opening into special apertures. Skeleton complicated, calcareous, composed of thick plates closely articulated together; their number and arrangement are determinate in the different families, the multiples of five being those which predominate; the central plate of the body is supported on a long, jointed column, that was firmly rooted to the sea-bottom. The mouth is central, and prominent; the vent is situated at its side; the arms are mostly ramose and multiarticulate, and when extended formed a net-like instrument of considerable dimensions. The mouth is always placed upwards, and retained so by the column being jointed to the central plate of the calyx. The normal station of the CRINOIDEA is the reverse of the ASTEROIDEA and ECHINOIDEA.

Type. *Pentacrinus Caput-Medusæ*, Miller. From the seas of the Antilles.

Extinct families of Crinoids have lived in all seas from the Silurian upwards, and only one or two representatives now exist.

From the above analysis of the class ECHINODERMATA, it appears that, as the *Sipunculoidea* and *Holothuroidea* are not found in a fossil state, and the *Blastoidea* and *Cystoidea* are special to the Palæozoic rocks, our field of investigation in this Monograph is limited to the ECHINOIDEA, ASTEROIDEA, OPHIUROIDEA, and CRINOIDEA, which we now propose to consider seriatim, commencing with the ECHINOIDEA.

Order—ECHINOIDEA.

The body is spheroidal, oval, depressed or discoidal, and enclosed in a calcareous test or shell, composed of ten columns of large plates, *the inter-ambulacral areas*, and ten columns of small plates, *the ambulacral areas*, separated from each other by ten rows of holes, *the poriferous zones*. The external surface of the plates is studded with tubercles of various sizes, in the different families; to these the spines are moveably articulated by ball-and-socket joints; the spines are of various forms and dimensions, and serve well to characterize the species.

At the summit of the test is the apical disc, composed of five genital plates, perforated for the passage of the ovarial and seminal canals, and five ocular plates, notched or perforated for lodging the eyes. There are two great openings in the test, one for the mouth and the other for the vent; the relative position of these apertures varies in different families, and forms an important character in their systematic classification.

The mouth in some families is armed with a complicated apparatus of jaws and teeth, in others it is edentulous. The internal organs of digestion consist of a pharynx, œsophagus, stomach, and intestine, which winds round the interior of the test, attached thereto by a delicate mesentery; its surface, as well as the lining membrane of the shell, is covered with vibratile cilia; these cause currents of water to traverse the interior of the body, and perform an important part in the function of respiration; the blood is circulated in arteries and veins, aided by a central pulsating organ or heart. The five ovaries and testicles occupy the ambulacral divisions, and open externally through holes in the genital plates. Locomotion is performed by the joint action of the tubular retractile suckers and the spines. Many sea-urchins attach themselves to rocks by their tubular feet, and some bury themselves in limestone and sandstone, or even granitic rocks, by the abrading action of the spines.

The nervous system consists, according to M. Van Beneden, of a circular cord, which surrounds the entrance to the digestive organs, and sends branches into the divisions of the body. Professor Agassiz, and the late Professor Edward Forbes, regarded the organs situated in the ocular plates as eyes, but M. Dujardin[1] denies them even a nervous system. In the absence of more direct anatomical evidence on the point, the following observation, related by M. Alcide d'Orbigny,[2] has an important bearing on the question, and supports it affirmatively:

Captain Ferdinand de Candé, who commanded the 'Cléopâtre' in the Chinese seas, told M. d'Orbigny that he had captured, on the coast of that region, an urchin with long spines, probably a *Diadema*, which he examined in a vessel of water, "I hastened to

[1] Lamarck, 'Animaux sans Vertèbres,' 2nd ed., tom. iii, p. 200.

[2] 'Paléontologie Française, Terrain Crétacé,' tom. vi, p. 12.

seize it," he observed, "when it instantly turned all its spines in the direction of my hand, as if to defend itself.

"Surprised at this manœuvre, I made an attempt to seize it on the other side, when immediately the spines were directed towards me.

"I thought from this that the urchin saw me, and that the motion of the spines was intended as an act of self-defence; but, to prove whether the movement of the animal was produced by my approach, or merely by the agitation of the water, I repeated the experiment very slowly, and even over the water with a stick. The urchin, whether in the water or out of it, having always directed its defensive spines towards the object which approached it. From these observations I arrived at the conclusion that these urchins see, and that their spines serve them as defensive instruments."

It is worthy of remark, that Captain Candé, at the time he watched this urchin, was ignorant of the anatomical fact that eyes had been detected in the Echinidæ, and his inference was the conclusion drawn from carefully made observations.

The calcareous test of the Echinoidea is the only part of the structure of these animals preserved in a fossil state. It has hitherto failed to attract that amount of attention from the palæontologist which the importance of its study demands; although in a stratigraphical point of view this skeleton is not inferior to that of any other class of the Animal Kingdom. The fact seems to have been almost entirely overlooked by palæontologists, that most of the generic characters of the different groups of Echinidæ are more indelibly impressed on the separate pieces of their test than in the skeletons of any other class of the Invertebrata.

Unlike the shells of the Mollusca, the test of the Echinoidea constitutes an internal and integral portion of the animal, being secreted by, and enclosed within, organized membranes, it participates in the life of the organism, and certain parts of the skeleton are intimately connected with the organs of digestion, respiration, and generation, as well as with those of vision and locomotion.

As it is intended to give an analysis of the test of the Echinoidea, with anatomical details of the structure of the skeleton in the Echinodermata in general, in the General Introduction to these Monographs, it is at present unnecessary to enter minutely into the subject; but, as many of our readers are doubtless unacquainted with the terminology employed in the description of the test, and the characters on which a diagnosis of the species is made, it is desirable now to preface our description with brief explanations of the same, illustrating the terminology by a reference to the plates for accurate figures of different parts of the test, and magnified details of the anatomical characters thereof.[1]

[1] In connection with the physiology of the Echinodermata, the following discovery, made by Dr. Wallich, is most important:

"Thirteen living star-fishes, differing in no important particular from a species common on our own and most northern coasts, were brought up from a depth of 1260 fathoms, or very nearly a mile and a half, at a point midway between the southern extremity of Greenland and Rockall, and 250 miles distant from the nearest land. These star-fishes, however, cannot be said to have been captured by the sounding-

TERMINOLOGY,

Or a descriptive analysis of the component elements of the test of the Echinoidea.

The test of the Echinoidea is composed of the following parts:

a. Five ambulacral areas.
b. Five inter-ambulacral areas.
c. Ten poriferous zones.
d. Vent-opening and anal plates.
e. Mouth-opening, peristome, buccal membrane and plates.
f. Five jaws when organs of mastication exist.
g. Tubercles of various sizes, developed from the outer surface of the plates.
h. Spines of different forms and dimensions, jointed with the tubercles.

These are the essential parts to be known; others, of secondary importance, will be described in their proper place in the Monograph.

The body of the Echinoidea is divisible into three parts:—1st. The calcareous envelope, or skeleton, which has a globular, circular, oval, pentagonal, hemispherical, conoidal, or discoidal form, and is composed of a framework of hexagonal, pentagonal, or polygonal calcareous plates. This testaceous box is called the test; it is the *form*, the *test*, of Agassiz; the *general form*, the *test*, of Desmoulins; *le coquille*, d'Orbigny.

machine, for they came up adhering by their spine-covered arms to the last fifty fathoms of the sounding-line, not as voluntary exiles from below, but owing to their having coiled themselves around a material from which they found it impossible afterwards to disengage themselves. Now, apart from all other evidence, the facts in connection with this particular sounding were sufficient to indicate that the star-fishes had been raised from the sea-bed itself, and had not grasped the line whilst floating in some stratum of water intermediate between it and the surface. But, by a singular piece of good fortune, the question as to their last resting-place admitted of definite determination on evidence that they bore along with them. To comprehend the value of this, it is necessary to mention that, by means of a separate observation taken upon the same spot, the bottom was found to consist almost entirely of the minute shell-covered organisms (Foraminifera) already referred to; and taking into consideration the fact that many of the shells were completely filled with the gelatinous substance of which their bodies are composed, and, lastly, the fresh appearance of this substance, the probability is very great that they, in common with the star-fishes, had lived and multiplied at the bottom. But the only circumstance which ought to be accepted as direct proof of their vitality, namely, motion after reaching the surface, was wanting; as it well might be, since the passage through the vertical mile and a half of water occupied nearly an hour, and the change of conditions to which the creatures became subjected during that period must necessarily have been very great. Nevertheless, the chain of circumstantial evidence was rendered complete; for, on examining the stomachs of the star-fishes, they were found to contain the minute shelled creatures in abundance, thus clearly establishing the fact of the star-fishes having attached themselves to the sounding-line whilst it rested on the bottom, and adding the strongest confirmation to the view that the minute creatures referred to were brought up from their natural habitation." (Dr. Wallich, "On the Deep-Sea-Bed of the Atlantic, and its Inhabitants;" 'Quarterly Journal of Science,' No. 1, p. 40.)

2nd. The visceral cavity, containing the organs of digestion, respiration, circulation, and generation, is formed entirely by the interior of the test.

3rd. The external surface of the test is covered with spines, which are moveably articulated, with the tubercles seen on the surface.

The normal position of the body.—In describing the different parts of the test of the Echinoidea, it is assumed that an urchin, the common purple heart-urchin, *Spatangus purpureus*, Müller,[1] for example, is placed before the observer. The side with the single ambulacrum lodged in the anteal sulcus, and the mouth in that third of the base, is the *anterior region*. The side having the single inter-ambulacrum in the middle and the vent-opening in the upper part of the border is the *posterior region*. The four other ambulacra are disposed in pairs, and correspond to the right and left sides of the observer's body; there is, therefore, a right antero-lateral and a right postero-lateral, a left antero-lateral and left postero-lateral, ambulacral area. The four other inter-ambulacra, besides the single one in which the vent is situated, are likewise disposed in pairs, two of these, with the single ambulacrum, forming the anterior part, the other pair, with the pairs of ambulacra, the sides, and the single inter-ambulacrum the posterior part of the test.

All Echinoideæ have the mouth situated at the under side of the body; the surface in which the opening is placed is *the base*, that region of the test opposite the base is the *upper* or *dorsal surface*.

The most convex part of the margin, border, or sides, between the base and upper surface, is the *circumference*, or *ambitus* of some authors; it is round, flat, convex, angular, or carinated, according to the general form and thickness of the test.

The *length* or *antero-posterior* diameter is the distance between the anterior and posterior regions, and corresponds to the middle line of the body.

The *breadth* or *transverse* diameter is the distance between the greatest lateral convexity of the circumference in the direction of a line cutting the line of length at right angles.

The *height* is the distance between the most convex part of the upper surface and the plane on which the base of the test rests. The apical disc is generally situated at the vertex, but it is not always so; the height has always reference to the highest point of the test, quite irrespective of any other consideration. The test has invariably two openings, one for the mouth, the other for the vent.

The mouth-opening is always situated at the under surface; to its circumference is attached the buccal membrane, and through the central aperture thereof protrudes the five jaws (Pl. V, fig. 1; Pl. VII, fig. 1); when they exist, the buccal, like the anal membrane in many families, is clothed with numerous small plates.

In the *Cidaris, Rabdocidaris, Goniocidaris, Diplocidaris*, and probably in all other

[1] The common Chalk-urchin *Miraster cor-anginum*, Klein, will answer equally well.

Cidaridæ, the mouth-opening is central, circular, or slightly pentagonal (Pl. IV, fig. 16); but in *Hemicidaris*, *Pseudodiadema*, *Hemipedina*, *Pedina*, *Echinus*, and other *Echinidæ*, the mouth-opening is more or less decagonal, its margin being divided by notches (*entailles*) into ten lobes; the lobes, in general, are unequal in size, those corresponding to the base of the ambulacra being the largest; they are called the *ambulacral lobes;* corresponding to the base of the inter-ambulacra are the *inter-ambulacral lobes*. The margin of the mouth-opening is called the *peristome*, to it the buccal membrane which closes the base of the test is attached.

The *mouth-opening* is central and armed with jaws in the Cidaridæ, Echinidæ, Salenidæ, Galeritidæ, and Clypeasteridæ. It is more or less excentral and edentulous in the Echinonidæ, Collyritidæ, Echinolampidæ, Echinocorydæ, and Spatangidæ; in them it is round, oval, or pentagonal; sometimes its margin is ring-like, or surrounded by five prominent lobes; in others it is distinctly bilabiate.

The *vent*, or *anal opening*, is always in the upper surface, in the centre of the genital and ocular plates, directly opposite to the mouth, and is either central or subcentral in the Cidaridæ, Echinidæ, and Salenidæ (Pl. VI, fig. 1). In other families its position varies much; sometimes it opens on the upper surface, as in some Galeritidæ and Cassidulidæ. Sometimes it opens on the margin or is *supra-marginal*, marginal or *infra-marginal;* often it opens at the base between the mouth and the border. During the life of the animal this opening is closed by an anal membrane and a series of small angular anal plates; their number and disposition varies in the different genera. The anal plates are seldom preserved in fossil species, and the term anal opening is given to all that part of the test occupied by them and the vent. Pl. VI, fig. 1 *a*, is a magnificent specimen of *Cidaris sceptrifera*, Mant., belonging to the British Museum, in which the anal plates are finely preserved *in situ*.

The Ambulacral and Inter-ambulacral Areas.

The test is composed, 1st, of twenty columns of calcareous plates of different sizes, the *plaquettes*, *Täfelchen*, *Assulæ* of authors; they are pentagonal in form, and united by harmonial sutures to form rays, which proceed from the mouth, where they have their greatest breadth, to the apical disc, where they are narrowest. 2nd. Of a series of hexagonal or polygonal plates, forming a disc, which occupies the upper surface of the test. 3rd. Of ten rows of small plates, notched on their margins to form holes; these form the poriferous zones. 4th. Of moveable spines, that are jointed with eminences on the outer surface of the columnar plates.

The *ambulacral plates* form two narrow columns, which are bounded by two poriferous zones. The space thus circumscribed is the *ambulacral area*. There are five of these areas in the test of the Echinoidea. In the Cidaridæ the ambulacral areas are very narrow, and support only granules (Pl. VI, fig. 1, *a*, *b*, *c*, *d*). In the Echinidæ, they are much

wider, and have large tubercles on their surface. The comparative width of the ambulacra as compared with the inter-ambulacra has led some authors[1] to divide the family *Cidaridæ*, including therein the *Echinidæ*, into two tribes, the Angustistellæ, or Cidaridæ with narrow ambulacra, and the Latistellæ, or Cidaridæ with broad ambulacra. These two tribes nearly represent our two families; the Cidaridæ are equal to the Angustistellæ, and the Echinidæ are nearly equal to the Latistellæ.

One of the ambulacral areas is single, and always represents the anterior region in the spheroidal *Echinidæ* and *Salenidæ*. This is detected by its relation to the apical disc, as the right antero-lateral plate always carries the madreporiform body; in the oval, pentagonal, or elongated forms, its position and relation to the mouth renders it unmistakeable. The four other ambulacra are disposed in pairs.

The *inter-ambulacral plates* form two broad columns, composing the inter-ambulacral areas; of these, like the ambulacral, there are five, which alternate with them in the architecture of the test. The poriferous zones form the line of demarcation between these two classes of columnar plates. The plates are all pentagonal, and many times larger than the ambulacral; they carry on their surface the large primary tubercles. Of the five inter-ambulacral areas, one is single and posterior, and in all the Echinoideæ which have the anal opening external to the apical disc it is in the single inter-ambulacrum that the vent terminates. The other four inter-ambulacra are disposed in pairs, and form the greater part of the anterior and lateral parts of the test; they are the *anterior pairs* and *posterior pairs*, respectively, to distinguish them from the odd area, which is the *single inter-ambulacrum*.

Pl. VI, fig. 1, shows the form and structure of the inter-ambulacra in the *Cidaridæ*.

In the *Cidaridæ* the inter-ambulacral areas have only two rows of primary tubercles; but in many of the *Echinidæ* there are four, six, eight, or ten rows of primary tubercles in these areas.

The Poriferous Zones.

The poriferous zones are situated on each side of the ambulacral areas (Pl. VI, fig. 1); they are composed of a very great number of small pieces, articulated together in such a manner as to form a series of holes. The corresponding edges of the plates remaining uncalcified, at certain definite intervals produce foramina, which are destined for the passage of retractile tubular suckers. The form and structure of the poriferous zones form a good generic character. As there are two poriferous zones bordering each ambulacral area, it follows that there are ten zones. Some authors give the collective name *ambulacra* to the *zones* and the *area;* but for obvious reasons, I consider them distinct sections of the test, and treat them as such.

[1] Albin Gras, 'Description des Oursins Fossiles du département de l'Isère,' p. 20. E. Désor, 'Synopsis des Échinides Fossiles,' p. 26.

The pores are *round*, *oblong*, or *elongated;* the pores forming a pair may be *equal* or *unequal;* in relation to each other, they may be *transverse* or *oblique*, *contiguous* or *remote*, and when united by a transverse sulcus they are said to be *conjugate*.

The pores are differently arranged in the zones in the different families: when they are disposed in single pairs, they are said to be *unigeminal* (Pl. VI, fig. 1, *d*); when in double pairs, *bigeminal;* when in triple oblique pairs, *trigeminal;* and when grouped in a greater number, as in many living species of the genus Echinus, they are *polygeminal*.

When the zones extend in a straight uninterrupted line from the mouth to the apical disc, they are said to be *simple*, as in the *Cidaridæ*, *Echinidæ*, *Salenidæ*, *Galeritidæ*, *Echinonidæ;* when the zones, after parting from the apical disc, expand, and again contract, thereby forming a leaf-like figure on the upper surface of the test, they are said to be *petaloidal*, as in the *Clypeasteridæ;* when the petal is not so complete, as in the *Cassidulidæ*, it is *subpetaloidal*. The zones are *complete* when they extend without interruption from the mouth to the disc; they are *interrupted* when they terminate on the upper surface, and reappear again at the base near the mouth; they are *limited* when they form only a star on the dorsal surface. These terms represent generic characters of greater or less value, and require to be carefully noted in the description of the species.

The Apical or Genital Disc.

The apical disc occupies the centre of the summit of the test, and is composed in most genera of ten plates, namely, five genital plates and five ocular plates (Pl. VI, fig. 1, *a*). In the *Salenidæ* there is one or more additional plates introduced. *The five genital* or *oviductal plates* correspond to the summits of the inter-ambulacral areas; two plates form an antero-lateral pair, two a postero-lateral pair, and the single plate is placed behind. On the right antero-lateral genital plate (Pl. VI, fig. 1, *a*) is a spongy, prominent mass, called the *madreporiform body;* the plate supporting this body was supposed by Agassiz and Desor always to represent the posterior part of the test, but I have shown that it is invariably placed on the right antero-lateral plate.

The ocular plates are at the summit of the ambulacral areas; they are small, heart-shaped bodies (Pl. VIII, fig. 4, *b*), wedged into the angles of the genital plates around the circumference of the disc.

The suranal plates are found only in the Salenidæ; they consist of one or many elements placed in the centre of the genital circle, and always before the anal opening.

The anal plates (Pl. VIII, fig. 4, *b*), are very small bodies, and variable as to number; they clothe the membrane of the anal opening, and are well seen in recent urchins; but

are seldom preserved in fossil species; they are admirably shown, however, in the fine specimen of *Cidaris subvesiculosa* (Pl. VIII, fig. 4), from the collection of our kind friend, Dr. Bowerbank, F.R.S.

The Tubercles.

The plates composing the test of the *Cidaridæ*, *Echinidæ*, and *Salenidæ*, have large tubercles developed on their surface; they are divided into *primary tubercles*, *semi-tubercles*, *secondary tubercles*, *minute tubercles*, *granules*, and *miliary granulation*. In the other families the tubercles are smaller, more numerous, and less complicated.

The *primary tubercles* form two rows in the inter-ambulacral areas of the *Cidaridæ*, (Pl. I and II), and four, six, eight, ten, or twelve rows in many *Echinidæ*.

The *semi-tubercles* are found at the base of the ambulacral areas of the genus *Hemicidaris*. In a section of the genus *Hemipedina* they likewise are found at the base of the ambulacra.

The *secondary tubercles* are found in many of the *Echinidæ*, ranged, in general, on the ambulacral side of the primary tubercles. They are found likewise on the centro-sutural side of the primary rows of many *Pseudodiadema*, *Pedina*, *Hemipedina*, and *Echinus*.

The *minute tubercles* are the small tubercles found on the margins of the ambulacral areas of the genus *Cidaris* (Pl. VIII, fig. 1); and they sometimes fill up spaces at the base of the inter-ambulacral areas. In some *Pseudodiademata* they are raised on little eminences, and perforated like the secondary and primary tubercles. In this respect they are distinguished from the granules.

The *granules* are small, round, hemispherical elevations, scattered more or less regularly over different parts of the plates of the test. In some species of the genus *Cidaris* they are arranged in rows in the centre of the ambulacral areas, or form circles around the circumference of the areolas of the primary tubercles (Pl. VIII).

The *miliary granulation* is formed by a number of small granules closely set together in the centre of the ambulacra, or on the inter-tubercular surface of the large plates composing the inter-ambulacra (Pl. VIII, fig. 1).

The primary tubercles of the genera *Cidaris*, *Hemicidaris*, *Pseudodiadema*, *Hemipedina*, *Pedina*, &c., consist of the following parts:

The *hemispherical tubercle*, or *mamelon*, is sometimes perforated in the centre, sometimes imperforate, as in many *Echinidæ* (Pl. VII, fig. 3 *c*).

The *boss*, or *mammillary eminence*, is the conical prominence on the surface of the tubercular plate; its summit supports the tubercle, and the margin thereof is crenulated in *Hemicidaris* and *Pseudodiadema*, and smooth in *Hemipedina* and *Pedina*.

These characters are important for generic distinctions.

The *areola*, or *scrobicule* (Pl. VI, fig. 1, *d*), is the round, oval, or elliptical, smooth, excavated space which surrounds the base of the boss. This space is sometimes narrow, and its margin elevated into a ridge, that completely encircles it, when the *scrobicule* or *areolar circle* is said to be *complete;* if the upper and under sides of the circle are wanting, it is incomplete, and the areolas are then said to be *confluent*.

The row of granules encircling the areolas is called the *areolar* or *scrobicular circle*.

The *miliary zone* is the space comprised between two ranges of primary tubercles, it is in general covered with a close-set granulation; when destitute of miliary granules, it is said to be naked; the ambulacral and inter-ambulacral miliary zones occupy these different regions of the shell.

When the granules are microscopic, and closely clustered together within certain narrow, circumscribed bands, or *fascioles*, intersecting the general tubercular surface, and occupying fixed positions on the test, they are called *fasciolar*.

Fascioles are only found in two families, in one genus of the *Echinocoridæ*, and in almost all the genera of the *Spatangidæ*. The form, width, structure, and position of these bands must be carefully noted, as they afford important characters, both positive and negative, for the diagnosis of the genera.

When a fasciole surrounds the circumference of all the petaloidal portions of the ambulacral areas, it is *peripetalous;* if it encircles the single ambulacrum alone, it is *internal;* when it extends along the flanks, it is *lateral;* if it passes in whole, or in part, along the circumference, it is *marginal;* and when it surrounds the base of the single inter-ambulacrum, it is *subanal*. Sometimes there is only *one*, sometimes there are *two* or *three*, of these fascioles in different genera.

Each family has a special arrangement of the tubercles, granules, and fascioles; a detailed account of these will be found in the general outline of the structural characters prefixed to the description of each natural group.

The *sutural impressions* are the lines along which the plates are united together; sometimes they are mere lines; or the impressions amount to excavations out of the borders of the plates, and give rise to cavities therein, as in the genus *Temnopleurus*.

The *angular* or *sutural pores* are small impressions, situated in some genera at the angles of the plates, upon the median line of the miliary zones.

The external Appendages of the Test.

The *spines*, or *radioles*, as they were called by Plott, Lang, and other old authors, are the calcareous appendages that are moveably articulated to the tubercles of the test; they present numerous modifications as to size, form, and sculpture, which are all intimately

connected with specific characters ; some are short or elongated, flattened, cylindrical, fusiform, or subulate ; others are compressed, spatuliform, or triangular ; others, on the contrary, are expanded, pyriform, or claviform. The surface of the spines is smooth or striated with fine or coarse longitudinal lines ; some have verticillate processes at regular intervals, others have asperities, prickles, or granules, disposed with more or less regularity over the surface. The different parts of the spine have received the following names :

The *articular cavity*, or *acetabulum*, is the socket by which the spine articulates with the tubercle ; its margin is smooth or crenulated, according as the summit of the boss is smooth or crenulated (Pl. VI and VII) ; in all the genera with perforated tubercles there is a corresponding pit in the socket of the spine, for the attachment of the round ligament which passes from the tubercle to the spine.

The *head* is that part of the spine containing the articulating cavity, and is united to the stem near the neck (Pl. VII, fig. 4).

The *milled ring* surrounds the head ; it is a prominent ridge, more or less deeply crenulated, around which the muscular fibres that move the spine are firmly attached.

The *neck* is the smooth space between the line of junction above the milled ring and the rugose body of the spine (Pl. VII and VIII). In long, slender, tapering spines, it is often finely striated with longitudinal lines, and cannot be distinguished from the body into which it passes.

The *stem* or *body of the spine* is the part that exhibits the greatest variety of forms, smooth and muricated varieties are figured in Pl. I, II, IV.

The organs of mastication forming "the lantern of Aristotle" are rarely preserved in fossil species ; they consist of five jaws, each carrying a long tooth (Pl. V and VII). As these parts form a complicated mechanism, their analysis and description will be given at length in the anatomical part of the introduction.

On the relative value of the external organs in the classification of the Echinoidea.

The mouth is always basal, central, subcentral, or excentral, but the excentricity is invariably towards the anterior border. This opening does not, therefore, afford a character of primary importance, although, in connection with others, it is valuable in the definition of families. The mouth is sometimes armed with jaws, but it is oftener edentulous.

The position of the anal opening affords a character of primary importance. In one great section the vent opens *within* the centre of the apical disc, surrounded by the genital and ocular plates. The relation, therefore, of the digestive organs to those of generation and vision, is an important primary character for the zoologist. In another section the vent opening is *without* the apical disc, and is more or less external to, and at a greater or less distance from, the genital and ocular plates. The physiological importance of the external relation of the organs of digestion, generation, and vision, to each other, imparts great

value to the position of the anal opening; and hence it forms the basis of the subdivision of this order into two sections, which are thus defined:

Echinoidea endocyclica.

A. Test circular, spheroidal, more or less depressed, rarely oblong; mouth in the centre of the base. Vent in the centre of the upper surface, directly opposite to the mouth, surrounded by five perforated genital plates, and having external to them five ocular plates. Mouth always armed with five powerful calcareous jaws, formed of many elements, disposed in a vertical direction.

Echinoidea exocyclica.

B. Test sometimes circular and hemispherical; oftener oblong, pentagonal, depressed, clypeiform, or discoidal; mouth central or ex-central. Vent external to the circle of genital and ocular plates, never opposite the mouth, and situated in different positions in relation to that opening: four of the genital plates are generally perforated. The mouth is sometimes armed with five jaws, oftener it is edentulous. The elements of the lantern are disposed in a more or less horizontal direction.

The structure of the ambulacral areas, and poriferous zones, afford good characters of secondary importance for grouping the genera into natural families, especially when taken in connection with the position of the vent, which varies in its relation to that of the mouth-opening in different families.

The form, number, and arrangement of the tubercles, and the spines that are jointed with them; the miliary granulation; the bands of microscopic granules forming the fascioles, having permanent positions on the test; also the size and number of the elements of the apical disc, and the position of the vent, afford collectively good characters for defining the genera.

The minute details of the structure of the plates; the form, size, and number of the tubercles on each of them; the arrangement of the pores, their proximity or remoteness from each other in the zones; the general outline of the test, which has only certain limits of variation; the form of the areolas; the presence, absence, size, and distribution, of the granules forming the scrobicular circle; the completeness or incompleteness of the same; the length of the spines, their form and sculpture, are points affording good specific characters, as they are persistent details that are developed on every considerable fragment of the test and spines of the Echinoideæ.

Taking these general principles for my guidance, I subdivide the Echinoidea into the following thirteen natural families:

Order—ECHINOIDEA.

- *Echinoidea endocyclica.* Vent within the genital plates, always opposite the mouth.
  - Cidaridæ.
  - Hemicidaridæ.
  - Diademadæ.
  - Echinidæ.
  - Salenidæ.
- *Echinoidea exocyclica.* Vent without the genital plates, never opposite the mouth.
  - Echinoconidæ.
  - Collyritidæ.
  - Echinonidæ.
  - Echinobrissidæ.
  - Echinolampidæ.
  - Clypeasteridæ.
  - Echinocoridæ.
  - Spatangidæ.

Family 1. CIDARIDÆ.—Test thick, spheroidal; inter-ambulacral areas very wide; primary tubercles large, perforated; bosses crenulated or uncrenulated, spines large, thick, mostly claviform; ambulacral areas very narrow; poriferous zones narrow, pores unigeminal, rarely bigeminal; mouth-opening large, inferior, central, circular or pentagonal; peristome destitute of notches, always armed with large, powerful jaws. Vent-opening wide, superior, opposite the mouth, surrounded by five large genital plates perforated for the ovarial canals, and five small ocular plates excavated for lodging the eyes; buccal and anal membranes covered with scales.

Types. *Cidaris clavigera*, König (Pl. IV). *Cidaris sceptrifera*, Mantell (Pl. VI).

Family 2. HEMICIDARIDÆ.—Test thick, spheroidal, or more or less depressed; ambulacral areas narrow or wide, with semi-tubercles at their base only, or extended throughout the area; inter-ambulacral areas with two rows of primary tubercles, rarely more than eight in each row; tubercles of both areas perforated, and bosses deeply crenulated; poriferous zones narrow and undulated; pores unigeminal throughout, except near the peristome, where they are bigeminal and trigeminal. Mouth-opening large; peristome decagonal, and divided more or less deeply by notches into ten lobes; jaws large and powerful; apical disc small, opposite the mouth, composed of five genital and five ocular plates. Spines long, thick, cylindrical, tapering, claviform, or stout, compressed, or angular; surface smooth, or covered with fine longitudinal lines, as far as known, neither prickles nor asperities are developed thereon.

Types. *Hemicidaris intermedia*, Fleming. *Acrocidaris formosa*, Agassiz.

Family 3. DIADEMADÆ.—Test thin, circular, or pentagonal, more or less depressed;

ambulacral areas wide, with two or four rows of primary tubercles; inter-ambulacral areas with two, four, six, or more rows of tubercles, nearly of the same size and structure as those of the ambulacra; tubercles perforated or imperforated, crenulated or uncrenulated, in different genera; apical disc small, opposite the mouth, composed of five genital and five ocular plates; poriferous zones narrow; pores unigeminal or bigeminal. Mouth-opening large and decagonal; peristome divided into ten lobes by deep notches; spines long, cylindrical, more or less slender, either tubular or solid; sometimes encircled by spiral verticillate processes, or their surface is sculptured with fine longitudinal lines.

Types. *Astropyga radiata*, Leske. *Cyphosoma Kœnigii*, Mantell. *Pseudodiadema tumidum*, Forb.

Family 4. ECHINIDÆ.—Test thin, spheroidal; inter-ambulacral areas, with small primary tubercles, of various sizes, perforate or imperforate; bosses crenulate or uncrenulate; ambulacral areas wide, always supporting two or more rows of primary tubercles; poriferous zones narrow or wide, pores unigeminal, trigeminal, or polygeminal, and disposed in arcs; spines short, mostly subulate. Mouth-opening large, inferior, always decagonal; peristome divided into lobes by notches more or less deep. Vent small, superior, opposite the mouth, surrounded by five genital and five ocular plates; buccal membrane naked.

Types. *Echinus sphæra*, Müller. *Codiopsis Doma*, Desmarest.

Family 5. SALENIDÆ.—Test thin, spheroidal; inter-ambulacral areas wide, with few primary tubercles, either perforate or imperforate, crenulate or uncrenulate; ambulacral areas narrow, carrying secondary tubercles. Mouth-opening small or large, inferior, decagonal; peristome more or less notched. Vent superior, surrounded by the plates of a large apical disc, composed of more than ten pieces, occupying a wide aperture in the superior part of the test. Poriferous zones narrow, pores unigeminal, except near the peristome, where they are trigeminal. Spines long, subulate, circular, or flattened. Species all extinct; the genera distributed in the Oolitic, Cretaceous, and Tertiary rocks.

Types. *Salenia petalifera*, Defrance. *Acrosalenia hemicidaroides*, Wright. *Goniophorus lunulatus*, Agassiz. *Hyposalenia Wrightii*, Desor.

Family 6. ECHINOCONIDÆ.—Test thin, circular, elongated or pentagonal, elevated or depressed; inter-ambulacral areas wide, ambulacral areas narrow; external surface of the plates covered with numerous small, perforated, and crenulated tubercles; poriferous zones narrow, pores unigeminal, except near the base, where they are trigeminal. Mouth-opening inferior, central, circular, or pentagonal, armed with five jaws; peristome

notched, dividing the circumference into ten nearly equal lobes. Apical disc central, superior, composed of five genital and five ocular plates; madreporiform body large, extending from the right antero-lateral genital plate into the centre of the disc. Vent situated at the upper surface, in the margin, or at the inferior surface of the test. Spines small, short, subulate. Species all extinct; genera distributed in the Oolitic and Cretaceous rocks.

Types. *Echinoconus albo-galerus*, Klein. *Pygaster semisulcatus*, Phillips. *Discoidea cylindrica*, Lamarck.

Family 7. Collyritidæ.—Test thin, circular, or oval; ambulacral areas meeting at two points, more or less apart, on the upper surface; poriferous zones narrow, pores unigeminal; tubercles small, numerous, perforated, and crenulated. Mouth-opening excentral, small, round, oval; peristome feebly fissured; jaws unknown. Vent round, oval, supra-marginal; elements of the apical disc detached; four genital holes. Species all extinct, and distributed in the Oolitic and Cretaceous rocks.

Types. *Collyrites ringens*, Desmoulins. *Collyrites ovalis*, Parkinson.

Family 8. Echinonidæ.—Test thin, oval; poriferous zones narrow, meeting at the apical disc; pores unigeminal; tubercles of both areas nearly equal, neither perforated nor crenulated; spines stout, subulate. Mouth-opening nearly central, irregularly pentagonal, and edentulous. Vent oblong or pyriform, basal or marginal, closed by anal plates; apical disc nearly central; four genital pores. One group living in tropical seas; another fossil in the Cretaceous rocks.

Types. *Echinoneus cyclostomus*, Leske. *Pyrina Desmoulinsii*, D'Archiac.

Family 9. Echinobrissidæ.—Test thin, circular, oblong, sub-pentagonal or clypeiform, covered with microscopic perforate tubercles, surrounded by excavated areolas; ambulacra narrow, enclosed by poriferous zones, more or less petaloidal; pores set at different distances apart, and united by connecting sutures. Mouth-opening small, nearly central, pentagonal, edentulous, in general surrounded by five lobes. Vent, opening in a sulcus, in the upper surface of the single inter-ambulacrum, or in a marginal depression thereof; apical disc small, four genital plates; madreporiform body extending into the centre of the disc. Species living and extinct, the latter distributed in the Oolitic, Cretaceous, and Tertiary rocks, the former in the seas of New Holland, and the Antilles.

Types. *Echinobrissus clunicularis*, Llhwyd. *Clypeus Plotii*, Leske. *Catopygus carinatus*, Goldfuss. *Pygaulus cylindricus*, Desor.

Family 10. Echinolampidæ.—Test thin, oblong, oval, elevated, or sub-discoidal; ambulacra large, petaloid; poriferous zones wide; pores apart, and united by suture; zones extending near to the margin. Mouth small, surrounded by five lobes,

Vent transversely oblong, and infra-marginal; apical disc small, excentral, with four genital holes. Some species are now living in warm seas, but the greatest number are extinct, and distributed in the Oolitic, Cretaceous, and Tertiary rocks.

Types. *Conoclypus Leskei*, Goldfuss. *Echinolampas orientalis*, Gray. *Pygurus Kœnigi*, Gray.

Family 11. CLYPEASTERIDÆ.—Test thick, elevated or depressed, circular, elliptical, or pentagonal; surface closely covered with small, nearly equal-sized tubercles, sunk in the plates, and surrounded by ring-like areolas, tubercles carrying short hair-like spines. Mouth large, central, and pentagonal, armed with five strong jaws, containing the same number of teeth. Vent posterior, marginal or infra-marginal; interior of the test divided by pillar-like processes, formed of the inner layer of the plates. The dorsal portions of the ambulacral areas have a petaloid form, circumscribed by large poriferous zones; the basal portions are narrow, rectilineal, or branched; the five genital plates form a circle round the madreporiform body, and between these are wedged the five ocular plates. This family includes the genera *Clypeaster*, Lamk., *Laganum*, Klein, *Echinarachnius*, Van Phels., *Arachnoides*, Klein, *Scutella*, Lamk., *Dendraster*, Agass., *Lobophora*, Agass., *Encope*, Agass., *Echinodiscus*, Breynius, *Mellita*, Klein, *Runa*, Agass., *Moulinsia*, Agass., *Scutellina*, Agass., *Echinocyamus*, Van Phels., *Fibularia*, Lamk., *Lenita*, Desor.

Types. *Clypeaster rosaceus*, Lamarck. *Scutella subrotunda*, Lamarck. *Echinarachnius placenta*, Gmelin.

Family 12. ECHINOCORIDÆ.—Test thick, oval or cordate, and sometimes conoidal; ambulacral areas contracted; poriferous zones narrow, pores unigeminal; test covered with small perforated and crenulated tubercles. Mouth small, excentral, tranversely oblong. Vent nearly of the same size, oblong, marginal or supra-marginal. Apical disc elongated, nearly central, with four genital pores; the cordate forms have an anterior central depression, and one genus has a marginal fasciole. The species are all extinct, and limited to the Cretaceous rocks.

Types. *Echinocorys vulgaris*, Breynius. *Holaster subglobosus*, Leske. *Cardiaster granulosus*, Goldfuss.

Family 13. SPATANGIDÆ.—Test thin, oval, oblong or cordiform, exhibiting the bilateral symmetry of the Echinoidea. Vent posterior and supra-marginal, closed by a complicated series of small plates. Apices of the ambulacral areas united at the summit of the test. The single ambulacrum has a different structure from the antero- and postero-lateral pairs, and is lodged in general in a depression of the test, which extends to the anterior border, and forms the anteal sulcus; test extremely thin, and covered with small tubercles, which support hair-like spines. Besides these there are some larger

crenulated and perforated tubercles for supporting large spines. There are two or four genital pores, placed close together in some genera, but apart in others. The eye-plates, five in number, are situated at the apices of the ambulacra, in a pentagonal form, around the genital plates. On the surface of the test of some *Spatangidæ* certain delicate lines are observed, having a smoother appearance than the tubercular surface of the test; these are the *fascioles*, which are strewed with microscopic tubercles, and destined to carry very delicate spines. The fascioles have a different disposition in each genus, and afford a good character in making definitions of the same. When the fasciole surrounds the ambulateral petals like an undulating groove, as in *Hemiaster*, *Schizaster*, &c., it is *peri-petalous*; when it surrounds the single ambulacrum, as in *Amphidetus*, it is *internal*; when it extends along the sides, as in *Schizaster*, it is *lateral*; when it surrounds the circumference of the test, as in *Pericosmus*, it is *marginal*; when it is limited to the base of the anal opening, it is *sub-anal*. Sometimes, in the same genus, more fascioles than one exist; thus the sub-anal and peri-petalous are frequently associated together.

Types. *Spatangus purpureus*, Müller. *Brissus lyrifer*, Forbes. *Brissopsis Ducici*, Wright.

Family 1—Cidaridæ.

Test thick, turban-shaped, more or less depressed at the oral and anal apertures. Mouth-opening wide, central; peristome circular or pentagonal, without notches; aperture closed by a buccal membrane, covered with small spines, metamorphosed into imbricated scales, upon which the pores from the zones are prolonged.

Opening for the apical disc very large; disc composed of five large, equal-sized, angular, genital plates, and five ocular plates; vent opening in the centre, directly opposite the mouth; anal membrane clothed with small angular plates, unequal in size, and variable in number.

Ambulacral areas extremely narrow, composed of a great number of very small plates, having only minute tubercles, or rows of small granules on their surface, and never supporting tubercles with primary spines.

Inter-ambulacral areas very wide, composed of large plates, rarely more than from six to eight in a column; the external surface of each plate carries a large perforated tubercle, raised on a prominent boss, and encircled by a round or oval areola, having an elevated margin, on which are a circle of granules, usually larger than those filling the miliary zone.

Poriferous zones narrow, extending without interruption from the margin of the buccal membrane to the apical disc; pores in general unigeminal, in one genus bigeminal; pores contiguous, or separated by septa more or less thick.

Jaws, five in number, forming a very powerful lantern, moveably connected with, and supported by, a series of calcareous processes or auricles, arising from the inner surface of the test; the teeth are more simple, and the lantern less complicated than in the *Echinidæ*.

The spines in this family exhibit a great variety of forms, they are large, strong, cylindrical, fusiform, prismatic, club-shaped, or flattened; and their surface is covered with fine longitudinal lines, or with prickles or granules, having in general a linear arrangement, or a more or less irregular disposition; the form and sculpture of the spine has a specific value, as its dominant characters appear to be persistent.*

The *Cidaridæ* are the most ancient type of the Echinoidea. The remains of different forms of this family are found in the Palæozoic rocks, as well as in those of the Secondary

* The form and general character of the spine should, in every case, be examined with scrupulous attention, and, whenever in fossil species the spines are found attached to their test, the facts connected therewith should be noted with the greatest accuracy. The neglect of this caution has been the cause of much confusion, and led to some serious errors.

and Tertiary epochs. In his valuable Synopsis, M. Desor describes six genera in this family: these are *Cidaris*, Klein; *Rabdocidaris*, Desor; *Diplocidaris*, Desor; *Porocidaris*, Desor; *Goniocidaris*, Desor; *Palæocidaris*, Desor. Of this number three are extinct—*Diplocidaris*, *Porocidaris*, and *Palæocidaris*; two contain both extinct and living forms —*Cidaris* and *Rabdocidaris*; and one is only found living—*Goniocidaris*.

A.—*Species from the Gault.*

CIDARIS GAULTINA, *Forbes*, MS. Pl. I, fig. 2, *a*, *b*, *c*, *d*, *e*; fig. 3, *a*, *b*; fig. 4 *a*, *b*, *c*.

CIDARIS GAULTINA, *Forbes*. Morris's Catalogue of British Fossils, 2nd ed., p. 74, 1854.
— — *Woodward*. Memoirs of the Geological Survey, Decade v, expl., pl. v, 1856.

The specimen figured in Pl. I, fig. 2, belongs to the British Museum, and was kindly communicated by my friend, S. P. Woodward, Esq., F.G.S. It consists of five inter-ambulacral plates, and a trace of an ambulacral area, with a number of spines. Detached plates of this urchin resemble those of *Cidaris vesiculosa*, Goldf. In the large plate (fig. 2, *b*), magnified two and a half times, the depth is greater than the breadth; the wide circular areola is nearer the lower border, its margin is elevated, and surrounded by a circle of thirteen small tubercles, each set upon a distinct base; the boss is flat, its summit smooth, and the tubercle large and distinctly perforated; the rest of the plate is covered with a fine close-set granulation (fig. 2, *a*, *b*).

The remaining fragment of the ambulacral area is too imperfect for description.

The spines vary in form; they are in general long and slender, and taper slightly (figs. 2 and 3). The surface is covered with longitudinal ridges, the edges are distinctly serrated (fig. 2, *a*, and fig. 3, *b*), and the stem represents a miniature fluted column. The truncated summit shows a star-like structure (fig. 2, *c*), produced by the serrated ridges meeting around the circumference of a central circle. The neck is smooth, short, and thick (fig. 2, *d*, and fig. 3, *b*); the milled ring broad and flat, and covered with very fine lines; the head is short, and the acetabulum surrounded by a line (fig. 2, *d*).

In one of the broken spines that accompanies the plates the upper extremity is expanded and cup-like (fig. 4, *a*, *b*, *c*), whilst in the other spines the extremities are contracted and truncated (fig. 2, *a*, *c*).

Affinities and differences.—This urchin very closely resembles *Cidaris vesiculosa*, Goldf., found in the Chalk-marl of Essen and Ruhr. The resemblance is so great between the German and English forms, that without a comparison of specimens a correct diagnosis

cannot be given. In *Cidaris vesiculosa*, Goldf., the marginal circle of areolar tubercles is not so prominent as in *Cidaris Gaultina*, Forb., but the general character of the ornamentation on the plates is the same in both. The spines figured by Goldfuss closely resemble those of *C. Gaultina;* they have the same slender, elongated form, and fluted structure; most of them are spindle-shaped, and some have an expanded cup-like termination, like the spine fig. 4, *a*.

Locality and Stratigraphical Position.—*Cidaris Gaultina* is a very rare urchin. I only know the specimens contained in the Museum of the Royal School of Mines, and the subject of our figures, which belongs to the British Museum; both these fossils were obtained from the Gault at Folkstone. *Cidaris vesiculosa*, Goldf., on the contrary, has been collected from the Chalk-marl of Germany, and the Grey Chalk at Dover.

B.—*Species from the Upper Greensand.*

CIDARIS VELIFERA, *Bronn*. Pl. II, fig. 2 *a*, *b*, *c*, *d*, *e*, *f*; fig. 3 *a*, *b*; fig. 4 *a*, *b*.

CIDARIS VELIFERA, *Bronn*. Jahrb., p. 154, the name only, 1835.
— PISIFERA, *Agassiz*. Catalogus Systematicus, p. 10, 1840.
— VELIFER, *Bronn*. Index Palæontologicus ("= *Saleniæ* sp."), 1848.
— MICHELINI, *Sorignet*. Ours. Foss. de l'Eure, p. 18, 1850.
— GLOBICEPS, *Quenstedt*. Handbuch der Petrefactenkunde, p. 577, pl. 49, fig. 17, 1852.
— VELIFERA, *Woodward*. Mem. Geol. Surv., Decade v, pl. v, 1856.
— HEBERTI, *Desor*. Synopsis des Échinides Fossiles, p. 12, 1858.
— VELIFERA, *Desor*. Ibid., p. 34, 1858.
— — *Cotteau*. Paléont. Française; Echinides, pl. 1054, figs. 14—21, p. 241.

Test small, circular, depressed; ambulacral areas narrow and sinuous, with four rows of granules; inter-ambulacral areas wide, tubercles large and prominent, gradually increasing in size from the peristome to the apical disc, where they are globose and conspicuous; spines short, stems large and globular, surface covered with longitudinal rows of pustular elevations.

Dimensions.—Height, three tenths of an inch; transverse diameter, eleven twentieths of an inch.

Description.—This beautiful little Cidaris is one of the oldest representatives of the group possessing claviform spines, *Radioli glandarii*, for all doubt about the identity of the

test, and the spine appertaining thereto, is removed by the discovery of the interesting specimen figured in Pl. II, fig. 4, *a*. The spines of this species were first discovered in the Craie chloritée of Essen and Frohnhausen, and were named by Bronn *velifer;* as the asperities on their globular stem impart a peculiar character to them, and that author, in his 'Index Palæontologicus,' referred them to a *Salenia*. M. Desor described a small *Cidaris Heberti* from the Craie chloritée of Cap la Hève, which I believe to be the test of this species. The short diagnosis given in the 'Synopsis' agrees so well with the specimens before me that I have no hesitation in concluding it to be the same:—"*Petite espèce à scrobicules petits et serrés, mais à tubercules trés-gros, surtout à la face supérieure. Quatre rangées de granules ambulacraires.*"

The ambulacral areas are slightly sinuous, and furnished with four rows of small granules (fig. 2, *e*) closely set together, the marginal rows being the most uniform in their arrangement. The narrow poriferous zones lie in a deep groove formed by the prominence of the adjoining granules; the pairs of small holes are obliquely inclined, with thickened septa, each having a small tubercle (fig. 2, *e*) between them.

The inter-ambulacral areas have two rows of tubercles placed so near the poriferous zones that the inter-tubercular space in the middle of the area is about the same width as the ambulacra, whereby the ten rows of tubercles are situated nearly equidistant from each, thus imparting a regular appearance to this species (fig. 2, *c*, *b*). There are five tubercles in each row, which increase gradually in size from the peristome to the disc; the three basal tubercles are small and set closely together (fig. 2, *b*), whilst the two upper tubercles are large and wide apart (fig. 2, *c*); the mammillary eminence is depressed, the areolæ are narrow (fig. 2, *e*), and their margin surrounded by a circle of well-defined granules (fig. 2, *f*). The tubercle is large and prominent, and the narrow boss on which it rests is destitute of crenulations (fig. 2, *e*, *f*); the summits of all the tubercles are perforated, those on the upper part of the test are, however, best preserved. A broad band of granulations separates the two rows of tubercles; five or six rows of granules are closely placed together; and the granules in the band and those in the ambulacra are nearly of the same size.

In the specimen figured at 4, *a*, there are seven spines attached to the test in their natural order. The spines (fig. 3, *a*) have a very short neck and a large globular stem, covered with rows of pointed elevations (fig. 3, *b*) rising from the midst of an apparently villous surface. The milled ring (fig. 4, *b*) is close to the acetabulum, it is moderately prominent, and crowded with fine lines. From the manner in which these globular spines are arranged on this small test, very little individual motion was possible among them, and yet the delicate surface of the spines, when examined with a lens, gives no evidence of abrasion, from the friction of moveable bodies laid so closely together as these spines were placed.

Affinities and differences.—The test of this beautiful little Cidaris is nearly related to

Cidaris clavigera, König, both in the form of the tubercles and the narrowness and depth of the areolæ; but in the structure of the spines there is a manifest difference, which will be more fully appreciated by comparing Pl. IV, fig. 1, exhibiting a series of spines of *C. clavigera*, with Pl. II, fig. 3, *b*, showing a magnified view of the spine of *C. velifera*.

Locality and Stratigraphical Position.—W. Cunnington, Esq., F.G.S., of Devizes, to whom I am indebted for the loan of specimens of this species, obtained them from the Upper Greensand near Warminster; I had seen the plates of the test and portions of the spines, but never before have I seen these parts "in situ."

The foreign distribution of this urchin is as follows:—The spines are found in the Craie chloritée of Essen, Prussia, and of Frohnhausen, Hesse-Cassel, and the test, described under the name *Cidaris Heberti*, Des., was collected from the Craie de Vendome, from the Craie chloritée du Cap la Hève and la Madeleine, near Vernon (Eure) in l'Étage Cénomanien, where it is very rare.

C.—*Species from the Grey Chalk.*

Cidaris Carteri, *Forbes.* Pl. I, fig. 1, *a*, *b*, *c*, *d*, *e*, *f*.

Cidaris Carteri,	*Forbes.*	Memoirs of the Geol. Survey, Decade v, pl. v, 1854.
—	— *Morris.*	Morris's Catalogue of Brit. Fossils, 2nd ed., p. 74, 1856.
—	— *Desor.*	Synopsis des Échinides Fossiles, p. 12, 1858.

Test small, inflated, subconical; ambulacral areas narrow, winding, with two marginal rows of moniliform granules, and a deep median sulcus; inter-ambulacral areas wide; tubercles small, remote; areolæ at the equator narrow, complete, those on the upper plates small, elongate, and obsolete.

Dimensions.—Height, eight lines; transverse diameter, ten lines.

Description.—Should subsequent discovery confirm the opinion that this is an adult test, it will be the smallest Cidaris in the English Chalk. It very much resembles, in many points of structure, *Cidaris sceptrifera*, Mant., from which it differs, however, in size and figure, and in the development of the tubercles and their areolæ, especially those on the upper plates. The ambulacral areas are narrow and winding; they have two rows of prominent moniliform granules on the extreme margins of the areas (fig. 1, *c*); and in the depth of one equatorial inter-ambulacral plate I have counted sixteen of these; between them is a deep sulcus, on which two indistinct central rows of microscopic granules are sparsely distributed.

The inter-ambulacral areas are wide, and consist of large, deep plates (fig. 1, *c*), about four or five in each row, those at the equator are the largest; the tubercle is small and perforated; the boss is flat, with a smooth summit; the areolæ are narrow and complete, and encircled by a moniliform circle of sixteen small granules, raised on scale-like plates (fig. 1, *c*); from the equator to the mouth the tubercles and their areolæ gradually diminish in diameter, and on the upper surface the plates they are very deep, and their areolæ small, elongated, and entirely obsolete; the inter-tubercular surface of the plates is covered with close-set miliary granulations.

The poriferous zones are narrow and deeply sunk, in consequence of the thickness of the plate-ornamentation; the holes are small, the pairs oblique, and there are sixteen pairs opposite one large inter-ambulacral plate, one pair of holes being opposite one of the large marginal ambulacral granules.

The apical disc is wide, occupying all the summit of the test (fig. 1, *a*, *b*); the ovarial plates are large (fig. 1, *d*), and of an irregular rhomboidal figure; their surface is covered with small granules sparsely distributed thereon, and the oviductal holes are perforated at the outer third of the plates. The oculars are small and heart-shaped, and intercalated between the angles formed by the ovarials; the orbits appear to have been marginal.

Affinities and differences.—This species resembles *Cidaris sceptrifera*, Mant., but the depth of the inter-ambulacral plates and the limited number in a column, together with the smallness of the areolæ and the obsolete character of those on the upper plates, prove that this urchin is quite distinct from that form.

Locality and Stratigraphical Position.—The only specimen at present known was collected by James Carter, Esq., F.G.S., of Cambridge, from the Grey Chalk of that neighbourhood; and it belongs to his collection. In Morris's 'Catalogue' it was stated by mistake to have come from the White Chalk, and in M. Desor's 'Synopsis,' from the Grès vert supérieure d'Angleterre.

History.—This species was first figured in the 'Memoirs of the Geological Survey,' in plate v of the Fifth 'Decade of British Organic Remains.' The original specimen formed the subject of Mr. Bone's drawings for this work.

CIDARIS VESICULOSA, *Goldfuss*. Plate II, fig. 5, *a*, *b*, *c*, *d*; Plate III, fig. 1, *a*, *b*, *c*, *d*, *e*.

CIDARIS VESICULOSA, *Goldfuss*. Petref. Germaniæ, t. i, p. 120, pl. xi, fig. 2, 1826.
— — *Agassiz*. Prod. Mém. Soc. Nat. de Neuchatel, tom. i, p. 188, 1836.
— — *Desmoulins*. Études sur les Échinides, p. 332, No. 23, 1837.
— — *Bronn*. Lethæa Geognostica, p. 607, pl. xxix, fig. 76, 1837.
— — *Geinitz*. Charakter der Schichten und Petrefacten Kreidegebirges, p. 89, pl. xxii, fig. 1, *a*, *b*, *c*, *d*, 1839.
— — *Roemer*. Norddeutschen Kreidegebirges, p. 28, 1840.
— — *Dujardin*, in Lamarck, Anim. sans Vert., 2e ed., t. iii, p. 338, 1840.
— — *Reuss*. Versteinerungen der Böhm. Kreideform., p. 57, pl. xx, fig. 14, 1845.
— — *Agassiz* et *Desor*. Catal. rais. des Éch. Ann. des Sc. Nat., 3e série, t, vi, p. 328, 1846.
— — *Bronn*. Index Palæont., p. 301, 1848.
— — *Quenstedt*. Handbuch der Petrefacktenkunde, p. 575, pl. xlviii, fig. 47, 1852.
— SPINULOSA, *Guéranger*. Essai d'un rèp. paléont. de la Sarthe, p. 40, 1853.
— VESICULOSA, *Desor*. Synopsis des Échinides Fossiles, p. 11, pl. v, figs. 24, 25, 1855.
— RŒMERI, *Cotteau*, in Davoust, Note sur les Fossiles spéciaux à la Sarthe, p. 49, 1855.
— VESICULOSA, *Pictet*. Traité de Paléont., 2nd ed., t. iv, p. 254, 1860.
— — *Cotteau* et *Triger*. Échinides de la Sarthe, p. 133, pl. xxv, figs. 1—6, 1860.
— — *Cotteau*. Note sur les Échinides recueillis en Espagne, par MM. Verneuil, Triger, et Collomb., Bull. de la Soc. Géol. de France, 2e série, t. xvii, p. 375, 1860
— — *Cotteau* in D'Orbigny's Paléontologie Française, t. ii, p. 222, pl. 1050, and pl. 1051, figs. 1—6.

Test circular, inflated, nearly equally depressed at both poles; ambulacral areas flexed, depressed in the middle, and filled with from six to eight rows of close-set, nearly equal-sized granules, diminishing to two or four rows near the disc and peristome; poriferous zones very narrow, and flexuous; pores small, having a moniliform line of granules separating the pores; inter-ambulacra wide, four to five plates in each column; tubercles moderate in size, perforated, and uncrenulated, set very wide apart on the upper half of the test; areas round, superficial, much inflated at the border, and surmounted with a circle of prominent, mammillated granules. Near the disc the tubercles on the alternate columns become dwarfed, are destitute of areolæ, and occupy the middle of a long granular plate; miliary zone large, much depressed, and filled with small equal-sized granules; discal and oral apertures about the same diameter.

Dimensions.—Height, nine tenths of an inch ; transverse diameter one inch and a half.

Description.—This urchin, which forms so characteristic a species in the Lower Chalk of the Continent, as shown in the table of synonyms, has hitherto escaped the notice of English geologists. The species from our Upper Chalk, erroneously referred to this form, being quite distinct from the true *Cidaris vesiculosa*, Goldf., from the Gray Chalk and Upper Greensand ; specimens from each of these formations I have figured in Pls. II and III.

The test is of moderate size, much inflated at the sides, and nearly equally depressed at both poles ; the ambulacral areas are flexuous, depressed in the middle, and filled throughout with numerous rows of small, regular, close-set, equal-sized granules ; at the equator there are eight rows, which, near their terminations, diminish to two or four rows (Pl. III, fig. 1, *d*) ; the inner rows are those which gradually disappear, whilst the outer rows are persistent throughout.

The poriferous zones are very narrow, following the flexures of the ambulacra ; they are composed of small round pores, separated by a granule, the series forming a moniliform line down the middle of the zone, fig. 2, *d*.

The inter-ambulacral areas are composed of very large plates, those in the upper half of the columns being the largest and most inflated ; there are from four to five plates in each series. The areas are circular and superficial, with very prominent borders surrounded by a circle of distinct regular mammillated granules (Pl. III, fig. 1, *d*) ; on the under half of the test the tubercles are approximated (Pl. III, fig. 1, *b*) ; whilst on the upper half they are set wide apart, from the increased height of the plates (Pl. III, fig. 1, *a* and *c*) ; near the summit the uppermost tubercles on the alternate columns are imperfectly developed, and often destitute of areolæ, and placed in the middle of a long granular plate (Pl. III, fig. 1, *a* and *c*). The tubercles are moderate in size, and perforated ; the summits of the bosses are quite smooth, and without any trace of crenulations (Pl. III, fig. 1, *e*).

The miliary zone is large and much depressed, and provided with numerous flat, uniform granules, closely set together on the entire surface of the plates (fig. 1, *d*).

The peristome is circular (fig. 1 *b*), and the opening for the apical disc (fig. 1, *a*) is nearly the same diameter as the oval aperture.

The spines of this species, according to M. Cotteau, are elongated, cylindrical, subfusiform, with compressed longitudinal ribs, more or less spinous, and denticulated, the processes being always at regular distances apart. Towards the base, the ribs diminish and disappear, and the stem is provided only with fine, close-set striæ. The neck is short and striated, the milled ring prominent, the articular head smooth, and surrounded by a small groove.

Length, twenty-five to thirty millimeters ; thickness, five millimeters.

Variety, *spinulosas*, Agassiz : length, forty-seven millimeters ; thickness, six millimeters.

Affinities and differences.—This species is distinguished from *Cidaris sceptrifera*,

Mant., of the White Chalk, by having fewer tubercles in the columns, which are wider apart in the upper portion of the test; the areolas are likewise shallower, and the border more prominent. In *Cidaris sceptrifera* the tubercles are largely developed (Pl. VI, VII), with deep areolas surrounded by a circle of prominent granules, and with a narrow sinuous miliary zone. The spines likewise are large and fusiform, having their surface covered with prominent spiny granules. *Cidaris vesiculosa*, Goldf., differs from *C. subvesiculosa*, d'Orbig., in having the test flatter, the tubercles smaller, less numerous, and more apart.

The specimens of this urchin, collected from the Upper Greensand of Wiltshire, were by the late Professor Forbes[1] referred to *Cidaris insignis*, Gras. Through the kindness of my friend W. Cunnington, Esq., F.G.S., I have been enabled to examine the beautiful series of this species in his collection, and in Pl. II, fig. 5, have figured his largest and finest specimen. A careful study of these fossils has satisfied me that they are not the species described by Dr. Albin Gras,[2] and which he thus characterized :—" Aires ambulacraires ondulèes, paraissant présenter deux rangées verticales de granules très serrées et rapprochèes les unes des autres; probablement cinq tubercles inter-ambulacraires non crénelés dans chaque rangée (quatre paraissent seulement dans notre exemplaire, dont la partie supérieure manque). Sur les cinq tubercles, les trois inférieurs augmentent progressivement de grandeur en allant de bas en haut; leurs scrobicules et leurs cercles scrobiculaires ronds, saillants et formés de granules serrés, sont très-prononcés, tangents entre eux et avec ceux de la rangée voisine; ils sont au contraire presque effacée dans le petit tubercle qui vient ensuite, lequel diminue brusquement et repose pourtant sur une très-large plaquette couverte de nombreux granules." The ambulacral areas in *C. vesiculosa*, Goldf., have, at the equator, six rows of small, equal-sized granules, closely arranged in parallel lines, and diminishing to four rows at the narrowest parts. This persistent structure affords a character by which the species is distinguished from *C. insignis*.

The British Museum contains a fine specimen of *C. vesiculosa*, Goldf., from the Gray Chalk of Dover (Pl. III, fig. 1). This test I have carefully compared with Mr. Cunnington's Upper Greensand specimens, and the examination has convinced me that they belong to the same species; the test of the specimen from the Gray Chalk is that of a larger, and older individual; some of the plates, however, in the upper part of the columns, are proportionally more inflated; but in all other respects its characters are identical with those of the Upper Greensand forms.

The test is spheroidal, of medium size, and nearly equally depressed at both poles; the ambulacral areas form narrow, flexuous, granular bands, which decline towards the central suture; they are entirely filled with small, close-set, equal-sized granules, arranged in regular parallel rows, of which there are from six to eight at the equator, diminishing to four in the narrowest parts, near the peristome and apical disc; the poriferous zones

[1] Morris, 'Catalogue of British Fossils,' 2nd ed., p. 74.

[2] 'Description des Oursins Fossiles du département de l'Isère,' p. 21, 1848.

are very narrow, and the small pores are placed close together, each septum being surmounted by a little granule; there are 23 pairs of holes opposite one of the large plates.

The inter-ambulacral areas are formed of large deep plates, the limits of which are very distinctly defined by well-marked sutural lines; there are four or five plates in each column, those at the lower part of the test are small and regular (fig. 1, *b*), and those at the upper part of the column are large, deep, and rather irregular in figure, from the extreme prominence of the areolar margin (fig. 1, *a*, *c*); each plate, with the exception of the uppermost in each alternate column, supports a large primary tubercle; it is surrounded by a shallow circular areola; the boss is not prominent; and the summit is smooth, without a trace of crenulation; the tubercle is large, sessile, and perforated (fig. 1, *e*); the margin of the areola is very prominent, which, in the larger plates especially, produces an inflation of their surface, and probably suggested the specific name *vesiculosa* (fig. 1, *a*). A complete circle of mammillated granules, larger than those on other parts of the test, surrounds the margin of the areolæ, and forms a prominent boundary thereto (fig. 1, *d*). The uppermost plate in each alternate column, in most specimens, is either destitute of a tubercle, or represented only by a rudimentary warty body, without areola, and situated in the midst of a long, narrow, imperfectly developed plate, on all sides surrounded by granules.

The mouth is small and circular, and of the same diameter as the aperture for the apical disc, which is likewise entirely circular.

Locality and Stratigraphical Position.—The specimen figured in Plate III, fig. 1, belonging to the British Museum, was collected from the Gray Chalk, at Dover, and the one figured in Pl. II, fig. 5, belongs to my friend W. Cunnington, Esq., F.G.S., Devizes, and was obtained from the Upper Greensand of Wilts. The specimen in my own collection is from the Gray Chalk of Dover. I believe this urchin is very rare, as I have seen very few specimens in the different collections of Cretaceous fossils. The Rev. T. Wiltshire, F.G.S., has communicated a fragment, collected from the Red Chalk of Hunstanton Cliff, together with three detached spines, of the same species. I am inclined to refer to this species the specimen, figured in Pl. III, fig. 3, collected by C. B. Rose, Esq., F.G.S., from the Red Chalk, and kindly communicated for this work. The test is much defaced by friction, but still many of the more remarkable characters of the urchin are well preserved.

History.—This urchin was figured and described for the first time by Goldfuss, from some isolated plates and spines collected from the *creta margacea* of Westphalia; that author cites, as identical with *Cidaris vesiculosa*, a fragment from the White Chalk of England figured by Parkinson, but which belongs to another species, probably *Cid. perornata*, Forb. This error has led to much confusion, for we find *Cid. vesiculosa*, Goldf., cited in many English lists as having been obtained from the White Chalk of Kent, Sussex, and Wilts; whereas the new form now figured and identified with Goldfuss's species has

been collected only from the Gray Chalk of Dover and the Upper Greensand of Wilts. *Cidaris vesiculosa*, Forbes, is a very different form from the true *C. vesiculosa*, Goldf.; and I must refer the reader to the article on that species for more ample details. This species has been beautifully figured and well described by M. Cotteau, both in his Monograph on the Echinidæ of Sarthe, and his continuation of D'Orbigny's Échinides de Terrains Crétacés, in the Paléontologie Française, a work which has profited so much by M. Cotteau's extensive knowledge of this subject. This species has now been identified and figured as British for the first time.

CIDARIS BOWERBANKII, *Forbes*. Pl. II, fig. 1, *a—d*.

CIDARIS BOWERBANKII, *Forbes*, in Dixon's Geol. and Fossils of Sussex, pl. xxix, fig. 4, p. 330, 1850.
— — *Forbes*, in Morris's Cat. of Brit. Foss., 2nd ed. p. 74.

Test spheroidal, depressed, ambulacral areas with four or six rows of nearly equal-sized granules; inter-ambulacral areas wide, five or six large spinigerous tubercles, with small areolæ in each column; miliary zone wide, filled with small, close-set, equal-sized granules. Spines very large, thick, and inversely conical, stems short, the surface covered with irregular, longitudinal rows of granulated spines.

Dimensions.—Transverse diameter one inch; height unknown.

Description.—The body of this *Cidaris*, which is very nearly allied to *C. clavigera*, is more compressed above and below than in that species.

The ambulacral areas are occupied by four or six small, nearly equal, granular tubercles in each transverse row, and the poriferous zones are narrow and slightly sinuous.

The inter-ambulacral areas are wide; the spinigerous tubercles, five or six in each column, have small areolæ, without prominent margins; the miliary zone is flat, and undepressed; and the entire surface is thickly covered with minute nearly equal-sized granules, of which a circle of larger ones surround the border of the areolæ.

The primary spines, seen *in situ* on the test (fig. 1, *a*), are thick, almond-shaped, inversely conical bodies, with a short neck, into which the body suddenly contracts (fig. 1, *b*); the milled ring is broad and prominent (fig. 1, *c*), and the acetabulum has a narrow rim close to the ring; the surface is minutely granulated with small spinous points, arranged in regular longitudinal rows (fig. 1, *b*); the spines which clothe the granular tubercles are small, compressed, conical bodies, with a striated surface (fig. 1, *d*); several of these are found *in situ* on the plates of the test.

Affinities and differences.—This species most nearly resembles *C. clavigera*, König; it is distinguished from that species, according to Professor Forbes, by having "the ambulacral segments slightly broader in proportion to the inter-ambulacrals, and instead of their breadth being occupied by transverse series of about four granular tubercles, two of which are very small and inconspicuous, there are four, or, centrally, even six, nearly equal granular tubercles in each transverse row. The large spinigerous tubercles of the ambulacral plates are placed in areolæ, much smaller in proportion to the entire body than in *C. clavigera*, and the tubercles themselves are also smaller. The spaces between the rows of spinigerous tubercles are wider; they are thickly studded with nearly equal granules."

The spines of *C. Bowerbankii* resemble those of *C. clavigera;* but the club-shaped head occupies the entire stem in the former, whereas in *C. clavigera* the club-shaped head is carried on the long stem. Compare Pl. II, fig. 1, with Pl. IV, fig. 1—3.

Locality and Stratigraphical Position.—This species has been found only in the Gray Chalk of Dover. The fine specimen I have figured is unique, and belongs to the cabinet of our kind friend Dr. Bowerbank, F.R.S.

History.—First figured by Prof. Forbes, in Dixon's 'Geology and Fossils of Sussex,' who likewise established the species in that work. The same specimen has been kindly lent by Dr. Bowerbank to figure in this Monograph.

CIDARIS DISSIMILIS, *Forbes.* Pl. III, III *a*, figs. 1 and 2.

CIDARIS SCEPTRIFERA, *Forbes*, in Dixon's Geology of Sussex, pl. xxv, fig. 3.
— DISSIMILIS, *Forbes*, in Morris's Cat. of Brit. Fossils, 2nd ed., p. 74.
— — *Woodward*. Mem. Geol. Survey, Decade v, expl. pl. v.

Test small, depressed, ambulacral areas narrow, flexuous, with six rows of small granules; inter-ambulacral plates, four to five in a column; areolæ circular, wide apart, surrounded by distinct secondary tubercles; principal tubercles prominent, bosses slightly crenulated, the inferior oral tubercles minute, the uppermost discal, rudimentary, and without areolæ; miliary granules large and prominent; spines slightly fusiform, surface covered with longitudinal lines of prickles.

Dimensions.—A. Transverse diameter eleven lines; height six and a half lines.
B. Transverse diameter, one and one fifth inches.

Description.—This urchin resembles *Cidaris sceptrifera* in its general characters, but was separated from that species by Professor Forbes in his MS. notes on this *Cidaris.*

The test is small and depressed at both poles; the ambulacral areas are narrow, with six rows of granules at the equator, diminishing to two rows at the discal and oral apertures (Pl. III *a*, fig. 2, *c*).

The inter-ambulacral areas are wide, and the plates large, from four to five in a column; the areolæ are circular and wide apart, the margins prominent, and surrounded by distinct secondary tubercles; the boss is prominent and slightly granulated; the tubercle is moderate in size and perforated; the tubercles near the peristome are small (fig. 2, *b*), and those nearest the apical disc rudimentary (fig. 2, *a*), and destitute of true areolæ (fig. 2, *c*).

The miliary zone is wide and zig-zag, and covered with large prominent granules (fig. 2 *c*), among which smaller granules are irregularly strewed.

I have given in fig. 1 *a* a drawing of the fine specimen of this species from the late Mr. Taylor's collection, now in the British Museum, and in fig. 2, *a*, *b*, a larger specimen from the cabinet of the Rev. T. Wiltshire, F.G.S.

The spines, according to Mr. S. P. Woodward, are of two kinds, "the largest above twenty-four lines in length, slightly swelling above the collar (two and a half lines in diameter), and then tapering to a fine point; collar short, striated finely; shaft granulated in lines; spines of the lower surface very slender, three- to six-sided, serrated at the angles; spines of the areolar circles two lines in length, compressed and striated."

Fig. 1, *b*, is a spine of *C. dissimilis* belonging to the British Museum.

Fig. 2, *d*, *e*, *f*, are spines from the collection of the Rev. T. Wiltshire.

Affinities and Differences.—This urchin so closely resembles *C. sceptrifera* that it was identified as such by Professor Forbes in Dixon's Geology of Sussex; in his manuscript notes on more perfect examples he had separated it under the name *C. dissimilis*. All the best specimens known to me I have figured in Pl. III *a*.

Locality and Stratigraphical Position.—This species was collected by Messrs. Clarke, Dixon, Taylor, and the Rev. T. Wiltshire, from the Gray Chalk at Dover; the finest of these specimens I have now figured for the first time. Fig. 1, *a*, *b*, belonged to the late Mr. Taylor's collection, and is now in the British Museum. Fig. 2, *a*, *b*, *f*, and figs. 3 to 5, belong to the Rev. T. Wiltshire's cabinet.

History.—This *Cidaris* was referred to *C. sceptrifera* by Professor Forbes in his description of that species in Dixon's Geology of Sussex. The subsequent discovery of more perfect specimens induced him to separate it from that form under the name of *C. dissimilis* in the MS. notes he left on the Cretaceous urchins.

D.—*Species from the White Chalk.*

CIDARIS CLAVIGERA, *König*. Pl. IV, Pl. V, figs. 1—15.

		De Luc. Mém. sur un Échinide singulier Mém. Acad. Roy. des Sciences, t. ix, p. 467, pl. xii, 1763.
		Andreæ, J. G. R. Briefe aus der Schweiz nach Hannover Geschr. in dem Jahr., 1763.
CIDARIS PAPILLATA,	*var.*	*Leske.* Klein, Nat. disp. Echinoderm, p. 134, pl. xlvi, figs. 2 and 3.
—	SPINIS CLAVICULATIS,	*Parkinson.* Organic Remains, t. iii, pl. iv, figs. 1 and 21, 1811.
—	CLAVIGERA,	*König*, in Mantell's Geol. of Sussex, p. 194, pl. xvii, figs. 11 and 14, 1822.
—	—	*König.* Icones Fossilium Sectiles, 1825.
—	—	*Agassiz.* Prod. Mém. Soc. des Sc. Nat. de Neuchatel, t. i, p. 188, 1836.
—	—	*Desmoulins.* Études sur les Échinides, p. 383, No. 34, 1837.
—	PROPINQUA (pars)	*Desmoulins.* Ibid., p. 332, No. 22, 1837.
—	CLAVIGERA,	*Geinitz.* Charakter der Schict. und Petref. Kreidegebirges, p. 90, 1839.
—	—	*Agassiz.* Catal. Syst. Foss., p. 10, 1840.
—	—	*Hisinger.* Lethæa Suecica, pl. xxvi, figs. 5, 6, 1840.
—	—	*Roemer.* Norddeutschen Kreidegebirges, p. 28, pl. vi, fig. 7, 1840.
—	—	*Morris.* Cat. of Brit. Fossils., p. 49, 1843.
—	—	*Agassiz* et *Desor.* Cat. rais. des Éch. Ann. Sc. Nat., 3e série, t. vi, fig. 327, 1846.
—	—	*Reuss.* Versteinerungen der Böhmischen Kreideform., p. 57, pl. xx, figs. 17—20, 1846.
—	—	*Graves.* Essai sur la top. Géog. du dép. de l'Oise, p. 692, 1847.
—	—	*Bronn.* Index Palæontologicus, p. 298, 1848.
—	—	*D'Orbigny.* Prodrome de Paléont., t. ii, p. 273, Ét. 22, No. 1246, 1850.
—	—	*Sorignet.* Ours. de l'Eure, p. 1, 1850.
—	—	*Forbes,* in Dixon, Geol. of Sussex, p. 338, pl. xxv, figs. 10, 11, 14, 18, 19, 20, 1852.
—	—	*Quenstedt.* Handbuch der Petrefackt., p. 575, pl. xlviii, fig. 46, 1852.
—	—	*Forbes,* in Morris's Cat. of Brit. Fossils, 2nd ed., p. 74, 1855.
—	—	*Desor.* Synopsis des Échinides Fossiles, p. 12, pl. vi, fig. 15, 1855.
—	HEBERTI,	*Desor.* Ibid., p. 12, 1855.

Cidaris clavigera,	*Pictet.* Traité de Paléontol., 2nd ed., t. iv, p. 254, pl. xcviii, fig. 8, 1857.
— —	*Cotteau.* Paléontologie Française; Ter. Crétacé, t. vii, pl. 1069, 1070, 1071, p. 285, 1862.
— —	*Dujardin* et *Hupé.* Hist. Nat. des Zooph.; Échinodermes, p. 480, 1862.
— Heberti,	*Dujardin* et *Hupé.* Ibid.

Test circular, moderately inflated, of medium size, and nearly equally depressed at both poles. Ambulacral areas narrow, slightly flexed, with four rows of mammillated granules, the inner being smaller than the outer rows; inter-ambulacral areas wide, five very large tubercles in each row; areolæ deep, circular, and complete; margin surrounded by a circle of mammillated granules; tubercles large and imperforate, boss smooth; miliary zone wide, not depressed, furnished with large granules; peristome small, subpentagonal; apical disc large, subcircular; spines large, clavate, crowded with longitudinal, prickly ribs.

Dimensions.—Transverse diameter, one inch and three tenths; height, seven tenths of an inch.

Description.—The finest examples of this urchin extant are those now figured in Plates IV and V, the one belonging to my friend, Dr. J. S. Bowerbank, Pl. IV, the other to the British Museum, Pl. V, fig. 1; both these specimens were collected and developed by the late Mr. Taylor, and formed part of his collection of Cretaceous Echinodermata. Having had abundant materials at my disposal for the illustration of this species, I have endeavoured to give accurate figures of all parts of the test, as well as of the remarkable spines which armed it. An examination of the series I have figured will show how very much the spines, from different parts of the test, differ from each, and how cautious we ought to be in founding species of *Cidaris* on the spines alone.

The test is of medium size, circular, moderately inflated, and nearly equally depressed at both poles. The ambulacral areas are narrow, slightly flexed, and provided with four rows of granules; the external are the largest, and most regular, and are elevated on mammillated summits close to the border of the poriferous zones; the internal rows are composed of smaller granules, irregular in size, arrangement, and extent; towards the ends of the areas they diminish in size, and gradually disappear whilst the external rows are persistent throughout. A number of microscopic granules are irregularly scattered among the internal rows, and form a regular series at the angle of the external granules, on the border of the poriferous zones, and opposite each pair of holes.

The poriferous zones are narrow, depressed, and slightly flexed; the pores are large, round, and open, closely approximated to each other, and having small elevated granules on the septa (Pl. IV, fig. 1, *b*).

The inter-ambulacral areas are wide (Pl. IV, fig. 1; Pl. V, fig. 2, *a*, *b*), with five very large, prominent tubercles in each row; the areolas are narrow, deep, and circular, closely approximated near the peristome (Pl. V, fig. 2, *b*), and wide apart at the upper surface (Pl. V, fig. 2, *a*); the margin is surrounded by a circle of small mammillated granules (Pl. IV, fig. 1, *b*, *c*), a little larger than those which fill the miliary zone; the boss is small, and not prominent, and its summit quite smooth (Pl. IV, fig. *b*, *c*); the tubercle is very large and prominent (Pl. V, fig. 2; and Pl. IV, fig. 1, *b*, *c*); it forms three fourths of a sphere, and the surface is imperforate; the tubercle nearest the disc is sometimes surrounded by a rudimentary areola (Pl. IV, fig. 1, *a*; Pl. V, fig. 2, *a*), and placed wide apart from its penultimate fellow. The areolas at the under surface are so closely approximated that many of them are separated only by a single row of granules.

The apical disc (Pl. V, fig. 3) is wider in diameter than the peristome; the five ocular plates are large, with prominent orbits surrounded by a radiated structure; the ovarial plates have a rhomboidal figure, with the hole distant from the border; the anal plates are well preserved in the specimen fig. 3, in which sixteen plates remain *in situ;* the surface of all the elements of the disc is covered with small granules, set well apart from each other; fig. 3 shows the disc and its elements magnified two and a half times.

The jaws and teeth are *in situ* in the specimen belonging to the British Museum (Pl. V, fig. 1); the peristome is small (fig. 2, *b*); and more than half the opening was filled by a buccal membrane, on which two or three rows of scale-like plates are disposed in an imbricated manner. Pl. V, fig. 4, exhibits the buccal membrane and its plates magnified two and a half times.

The form of the spines varies in different parts of the test. In general they are claviform, more or less developed, with massive bodies, elongated necks, and small articular heads. The body and neck are ornamented with numerous longitudinal ridges; those on the massive body develope a denticulated, spiny margin, as seen in Pl. IV, fig. 5, and in other series of spines figured in this plate. The denticulated ridges are sometimes prominent and regular, unequal, oblique, and rudimentary; on the neck the ridges are in general smaller, longitudinal, and with finer denticulations on the margin; at the inferior third of the neck they diminish in size and disappear, and are replaced by granules, which likewise fill up all the intermediate space between the ridges, both on the neck and massive head. In some spines, with a large head and short neck, the weight of the spine is diminished by a series of canals, which extend into the head beneath the spaces between the ridges; the head is sometimes traversed by a large channel, opening at the summit, as in a specimen (Pl. V, fig. 6) from the Rev. T. Wiltshire's collection. The collar is very small, and finely striated; the milled ring is narrow, and separated from the collar by a depression; both ring and depression being finely milled; the acetabulum (fig. 2) is moderately deep, with a well-defined ring round the margin. In Plate IV, I have figured the finest specimen extant of this species; it belongs to my friend Dr. Bowerbank, and shews two tests with their spines attached *in situ*. This specimen exhibits the various

forms of the spines in different regions of the shell, and the series of figures between 3 and 23 shows some of the extreme shapes these appendages assume.

Affinities and Differences.—This urchin is readily distinguished from other species of the White Chalk by its small test, equally depressed at both poles, narrow areolæ, prominent imperforate tubercles, and large claviform spines, more or less elongated, and covered with spinous ridges. In this respect it resembles *C. Bowerbankii*, Forb., Pl. II, fig. 1, from which it is distinguished chiefly by the character of the spines, and the larger size of the inter-ambulacral tubercles. Compare Pl. II, fig. 1, *a*, with Pl. IV, fig. 1.

Locality and Stratigraphical Position.—This is the most common *Cidaris* in our White Chalk; it is found at Woolwich, Gravesend, Lewes, Brighton, and in the same formation in Wilts and Dorset. The specimens figured in Pls. IV and V were found near Woolwich, and developed by the late Mr. Taylor. The grand specimen figured in Pl. IV is in the possession of Dr. Bowerbank, that in Pl. V, showing the dental apparatus, peristomal plates, and apical disc, belongs to the British Museum.

It is very abundant in the Étage Sénonien of France, and found, according to M. Cotteau, at Dieppe, Fécamp, Tancarville (Seine-Inférieure); Falaise (Somme); Vernonnet, Giverny, Clachaloze, Petit-Andelys, Pinterville près Louviers, Hougue-marre, Sinneville (Eure); Notre-Dame-du-Thil, Mory la Herelle, le Mesnil-Saint-Fermin, Pouilly Laboissière (Oise); Maintenon, Château-Gaillard (Seine-et-Oise); le Mesnil-Saint-Thomas (la Poterie) (Eure-et-Loire).

History.—This urchin was first figured and described by De Luc in 1763, and afterwards by Leske and Parkinson; in 1822 by Mr. Kœnig, in Mantell's 'Geology of Sussex,' who named it *C. clavigera*. The first accurate description of the test and spines was made by M. l'Abbé Sorignet, who pointed out the size and imperforation of its tubercles as important diagnostic characters. It has recently been well figured by M. Humbert for M. Cotteau in the 'Paléontologie Française;' and Mr. Bone has given most ample details from all the best English specimens that I am acquainted with.

CIDARIS SERRIFERA, *Forbes*, 1850. Pl. XI, fig. 1, *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, fig. 6.

CIDARIS CLAVIGERA, *Reuss.* Versteinerungen der Böhmischen Kreidef., p. 57, pl. xx, fig. 21, 1845.
— SERRIFERA, *Forbes*, in Dixon's Geol. and Foss. of Sussex, p. 338, pl. xxiv, figs. 15—19, and pl. xxv, fig. 2, 1850.
— PUNCTILLUM, *Sorignet.* Oursins Foss. de l'Eure, p. 9, 1850.
— SERRIFERA, *Forbes*, in Morris's Cat. of Brit. Foss., 2nd ed., p. 75, 1854.
— PUNCTILLUM, *Desor.* Synopsis des Échinides Foss., p. 15, 1856.
— — *Dujardin* et *Hupé*, Zoophytes; Échinodermes, p. 481, 1862.
— SERRIFERA, *Cotteau.* Paléontologie Française; Ter. Cret.; Échinides, tom. ii, p. 293, pl. 1071, figs. 5—15, 1863.

Test small, circular, convex above, flat below, poriferous zones narrow, depressed, slightly flexed, pores oval, approximated, separated by a small granule; ambulacral areas sinuous and depressed in the middle, with from six to eight rows of small, round granules; inter-ambulacral areas wide and inflated above, with four to five small perforated tubercles in each row, placed wide apart, with a miliary zone between them; spines long, slender, cylindrical, covered with longitudinal, compressed, spiny ribs, having a wide valley and granulated surface between them.

Dimensions.—Transverse diameter, one inch and one sixth; height, six tenths of an inch.

Description.—This beautiful urchin was distinguished by Professor Forbes from *C. clavigera*, for which it had been mistaken by Reuss, and was first figured in Dixon's 'Geology of Sussex;' it forms a well-marked species, which is very rare in our Cretaceous rocks. The test is small, and circular; inflated at the equator and upper surface, and flattened below; the poriferous zones are slightly flexed, narrow, and depressed; the pores are small, oval, and approximated; there is a granule between them on the septum; and an oblong transverse ridge between each pair. The ambulacral areas are narrow, and slightly undulated; the plates incline gently towards the median suture, and are provided with from four to six rows of small, close-set granules, of which the external rows are the largest, and raised on mammillated eminences; the smaller and shorter middle rows disappear near the disc and the peristome, where there are only the two external rows of mammillated granules; there are from fifteen to seventeen files of granules opposite one of the large plates. The wide inter-ambulacral areas are slightly inflated above and near the equator, and have from four to five deep plates in each series; the areolæ are small, and gradually increase in diameter from the peristome to the uppermost tubercle; on the uppermost plate of each alternate series the tubercle is nearly obsolete; the border of the areola is a little elevated, and surrounded by a circle of small, spaced-out, mammillated granules (fig. 1, *d*), a little larger than those which fill the miliary zone; the boss is small, the summit smooth, and the tubercle perforated in all the specimens I have seen; the inter-tubercular spaces and central miliary zone are filled with a fine, uniform, close-set granulation; on the upper part of the shell the tubercles nearest the disc are small, imperfectly developed, and surrounded by the merest trace of an areola; the sutures of the plates are depressed and conspicuous; the peristome (fig. 1, *b*) is small, circular or subpentagonal; the discal opening is larger than the peristome, and subpentagonal; a portion of the disc, concealed in the specimen (fig. 1, *a*), exhibits a finely granulated surface.

In a fossil I collected twenty years ago at Lewes, in Sussex, many of the spines are preserved *in situ* on the fragment of the test (fig. 1, *e*, *f*, *g*); they are long, slender, and cylindrical, having seven or eight compressed ridges, with a denticulated border; the

valleys between the ridges are concave, and the surface of these is very finely granulated; the neck is long and smooth (fig. 1, *f*, and fig. 2); it is bounded by a fine line, and beyond this is a narrow circle with microscopic lines conducting to a milled ring, which is prominent and finely sculptured (fig. 1, *f*, and fig. 2); the head is small, and the rim of the acetabulum striated; the small secondary spines are flat and conical (fig. 1, *h*), and have the surface ornamented with fine longitudinal lines.

Affinities and Differences.—This species is allied to *Cidaris vesiculosa*, Goldfuss, but distinguished from that form by having the test more regularly convex, the plates of the inter-ambulacra less inflated, and fewer tubercles in each series. The spines of the two species are likewise different. It resembles *Cidaris sceptrifera*, Mantell, but has smaller areolas, less prominent scrobicular circles, fewer tubercles in each column of plates; and the spines are very distinct (compare for example Pl. VII, fig. 1, with Pl. XI, fig. 1). According to Professor Forbes, it differs from *Cidaris subvesiculosa*, d'Orbigny, in having the inter-ambulacra composed of large plates with impressed areolæ around the spiniferous tubercles, four to six in the perpendicular row. Tubercles larger in proportion to the areolæ than in the last species. Superior plates with indistinct tubercles, but not so obsolete as in *C. subvesiculosa*. Granulated portion of the plates finely grained; the sutures are not impressed; the avenues of pores, of which about fourteen correspond to the largest plate, are broader in proportion to the ambulacra. There is a tubercle between each pore, and an oblong transverse ridge between each pair.

Locality and Stratigraphical Position.—I collected, about twenty years ago, a specimen of this urchin with the spines attached to the test, in the Upper Chalk, at Lewes, in Sussex; the example of this species figured in Dixon's work was obtained from the same locality. The fine fossil which I have figured in Pl. XI, fig. 1, was kindly communicated for this Monograph by Henry Willett, Esq., F.G.S., Brighton. This specimen appears to be the original fossil which was figured before by Sowerby in Dixon's 'Geology of Sussex;' if so, it formed the subject of Professor Forbes' observations.

In France this urchin is very rare; it was found in the Étage Sénonien at Civières, Giverny (Eure); Royan (Charente-Inférieure).

History.—This species was first well figured as *Cidaris serrifera* by Professor Forbes in Dixon's 'Geology of Sussex' in 1850. The same year M. l'Abbé Sorignet described it under the name *C. punctillum* in his work on the Fossil Urchins of the Department of the Eure; as this account was not accompanied by a figure, I have retained the name of the figured specimen. In 1845, Prof. Reuss figured this *Cidaris* in his fine work on the Fossils of the Bohemian Chalk-formation, and erroneously referred it to *Cidaris clavigera*, König, from which it differs in many important details both in the structure of the test and spines.

Cidaris sceptrifera, *Mantell.* Pl. V, figs. 16, 17; Pl. VI; Pl. VII, figs. 1, 2; Pl. VII *a*, figs. 1, 3.

Cidaris cucumerina,	*Parkinson.* Organic Remains, vol. iii, pl. iv, fig. 2, 1811.
— sceptrifera,	*Mantell.* Geol. of Sussex, p. 194, pl. xvii, fig. 12 (spine), 1822.
— —	*Agassiz.* Catal. Syst. Ectyp. Foss., p. 10, 1840.
— —	*Rœmer.* Norddeutschen Kreidegebirge, p. 28, 1840.
— cretosa,	*Morris.* Catalogue of Brit. Foss., p. 49, 1843.
— —	*Agassiz* et *Desor.* Catal. rais. des Échinides; Ann. Sc. Nat., 3e sér., t. vi, p. 328, 1846.
— vesiculosa,	*Reuss*, pars. Versteinerungen der Böhmischen Kreideformation, p. 57, pl. xx, fig. 15, 1846.
— sceptrifera,	*Graves.* Essai sur la Topogr. Géol. du Dep. de l'Oise, p. 688, 1847.
— —	*Bronn.* Index Palæontologicus, p. 298, 1848.
— —	*d'Orbigny.* Prod. de Pal. Strat., t. ii, p. 274, 1850
— —	*Sorignet.* Ours. de l'Eure, p. 6, 1850.
— —	*Forbes*, in Dixon, Geol. of Sussex, p. 338, pl. xxv, figs. 3—7, 1850.
— —	*Forbes*, in Morris, Catal. of Brit. Foss., 2nd edit., p. 74, 1854.
— —	*Desor.* Synopsis des Échinides Foss., p. 13, pl. v, fig. 28, 1855.
— —	*Woodward.* Mem. of the Geol. Survey, Dec. v, expl. to pl. v, fig. 12, 1856.
— —	*Leymerie* et *Raulin.* Stat. Géol. du Départ. de l'Yonne, pp. 510—620, 1858.
— —	*Coquand.* Synops. des Foss. Form. Crét. du Sud-Ouest de la France; Bull. Soc. Géol., 2e sér., t. xvi, p. 1013, 1860.
— —	*Cotteau* et *Triger.* Éch. du Dép. de la Sarthe, p. 253, pl. xlii, figs. 1—8, 1860.
— —	*Cotteau.* Paléont. Française, p. 251, pl. 1056-57-58, 1863.
— —	*Hupé.* Hist. Nat. Zooph.; Echinodermes, p. 480, 1862.

Test moderately large and inflated; more or less elevated, and nearly equally flattened at both poles; ambulacral areas narrow, depressed, flexuous, with six rows of granules in the middle, diminishing to four rows above and below; poriferous zones narrow, winding, and depressed; inter-ambulacral areas wide; plates very large, five to six in a column; areolæ deep, circular, with an elevated, prominent, scrobicular margin, encircled by a series of small granules, scarcely larger than those of the miliary zone; boss not prominent, summit feebly crenulated in young, and smooth in old shells; tubercle moderate in size and perforated; proximal discal plate in each column with a rudimentary tubercle, and an elongated obsolete areola; miliary zone filled with small, equal-sized granules, much

depressed along the line of all the sutures; apical disc wide; ovarial plates thick, large; ocular plates heart-shaped; spines long, cylindrical, fusiform, enlarged at the inferior third, and tapering gently to the summit; surface covered with regular, longitudinal rows of spiny, projecting granules, the intervening space being finely shagreened.

Dimensions.—Height, one inch and four tenths; transverse diameter, one inch and three tenths.

Description.—A very good figure of a fragment of the test and spines of this urchin was given in Parkinson's 'Organic Remains,'[1] pl. iv, fig. 2, and a fair drawing of the upper surface of the shell in pl. i, fig. 11; both were, unfortunately, unaccompanied by any description.

This beautiful species attains a considerable size; the test is circular, and nearly equally depressed at both poles (Pl. VI, fig 1, *c*); the ambulacral areas are very narrow and flexuous, with six rows of granules at the equator, diminishing to four rows at both poles; the external rows are the largest and most persistent, and the internal rows are found only in the wide portion of the area; in large shells there are many smaller granules, dispersed among the regular rows (Pl. VI, fig. 1, *d*); the poriferous zones are very narrow and depressed, following the flexures of the areas; the pores are small, round, closely approximated, and disposed obliquely, having a minute granule on the septum, and there are twenty-four to twenty-six pores opposite one of the larger plates (fig. 1, *d*).

The inter-ambulacral areas are very wide, and there are from four to five large plates in a column; in consequence of the prominence of the scrobicular circle, each plate is thickened at the middle, and the lines of sutures between the plates are all very much defined, in consequence of the plate sloping away from the scrobicular circle to the suture; the areolas are wide and circular, and surrounded by a thick, prominent border (fig. 1, *d*), encircled by a series of seventeen granules, each raised on a distinct, shield-like, mammillated plate; the boss is not prominent, its summit is feebly crenulated in young shells, and smooth in old ones (Pl. VI, fig. 1); the tubercle is moderately large and perforated; the plates near the peristome (Pl. VI, fig. 1, *b*) are disproportionately small compared with those of the equator (fig. 1, *c*, *d*); and the last plate of each column in old shells (fig. 1, *a*, *e*, *f*) has an elongated form, with a rudimentary tubercle, and curious elongated furrow, representing an obsolete areola. Mr. Bone has given most accurate drawings of this remarkable plate from the fine specimen in the British Museum; the singular star-like structure which these plates form on the upper surface of the test, surrounding the large apical disc, forms a remarkable character of this species, fig. 1, *a*.

The miliary zone is narrow, zig-zag, depressed in the middle, and provided with fine, close-set, nearly equal-sized granules, very much smaller than those surrounding the areolas.

[1] 'Organic Remains,' vol. iii, pl. iv, fig. 2.

The apical disc is very wide (Pl. VI, fig. 1, *a*); the ovarial plates are large, thick, irregular pentagons (fig. 1, *g*), and the ocular plates are heart-shaped; the surface of both series is covered with a close-set granulation; the ovarial and ocular holes are very conspicuous in this species; within the ovarials the external circle of anal plates are found *in situ* (fig. 1, *a*, *g*, *h*).

The mouth-opening (Pl. VI, fig. 1, *b*) is nearly circular, and smaller than the anal opening; the jaws are strong and powerful, as seen in Pl. VII, fig. 1, *a*, *b*.

The spines are long, cylindrical, and fusiform, thickest at the lower third, and tapering gently from thence to the point (Pl. VI, figs. 2—5); they are covered with small, spiny, equal-sized granules, the points of which are directed outwards; they are arranged in regular, longitudinal rows, with a valley between them; the prickles diminish in size near the collar, and at the summit of many of the large spines the rows of granules form a stellate termination (Pl. VI, fig. 3, *a*, *b*, *c*); the valleys are covered with a finely corrugated surface, the eminences forming microscopic longitudinal lines. The neck is very short and delicately striated (fig. 4, *b*), the head moderately large, and the milled ring not prominent; the rim of the acetabulum is feebly crenulated, and its concavity contains a deep depression for the round articular ligament; the length of the large spines, figured in Pl. VI, figs. 3 and 4, contained in the British Museum, is two inches and nine tenths. One figured by M. Cotteau, from the French Chalk, is three inches long.

Affinities and Differences.—*Cidaris sceptrifera* so closely resembles, in many points of structure, *Cidaris subvesiculosa*, d'Orbigny, that by some they have been thought to be varieties of one species; the facts on which their distinctness may be maintained are the following: *Cidaris subvesiculosa* has a more elevated test, with a greater number of plates in a column, the areolas are smaller and less depressed, the circle of scrobicular granules is less prominent, and the obsolete tubercles on the upper plates of the columns are smaller, more numerous, and differently formed; the granules covering the miliary zone are smaller, and more regularly disposed in rows radiating from the areola. The grand distinction is found in the spines, which are much smaller in *C. sceptrifera*, tapering, but not fusiform, and covered with longitudinal serrated lines. Compare the different excellent figures of *Cidaris subvesiculosa*, d'Orbigny, in Pl. VIII, with the admirable drawings of *Cidaris sceptrifera*, Mantell, in Pl. VI and VII.

Locality and Stratigraphical Position.—*Cidaris sceptrifera* is found in the Upper White Chalk of Kent, Sussex, and Wilts. The truly magnificent specimens figured in Pl. VI, fig. 1, and Pl. VII*a*, fig. 1, belong to the British Museum; the specimens figured in Pl. VI, fig. 2, and Pl. VII, fig. 1, belong to the Museum of the Royal School of Mines. I need scarcely add they are the finest known.

In France, M. Cotteau enumerates the following localities in which this species is found: Dieppe (Seine-Inférieure); la Faloise (Somme); Vernonnet, Giverny, Civières,

Petit-Andelys, Pinterville près Louviers, Senneville, Evreux (Eure); Notre-Dame-du-Thil Frocourt, les Blamonts, Therdonne, Pouilly, Reims, Broyes, la Herelle, le Mesnil-Saint-Firmin, Mory (Oise); Chalons-sur-Marne (Marne); la Ferté-Loupière (Yonne); Clachaloze, Maintenon (Seine-et-Oise); Marçon (Sarthe); Villedieu, Limeray (Loir-et-Cher); le Ménil-Saint-Thomas (la Poterie) (Eure-et-Loir); Aubeterre (Charente); Talmont, Saint-Georges, Royan (Charente Inférieure). Étage Sénonien. Saint-Paterne (Sarthe); Étage Turonien, zone *Terebratella Bourgeoisii*.

History.—First figured by Parkinson in 1811; the test and spines are both well drawn, so that no doubt as to the species intended can exist, although no description of the urchin was given. In 1822, Mantell figured one of the spines, and gave it the name which it still retains. This species was not indicated in France until 1840, when it was entered in M. Agassiz' *Catalogus systematicus;* since then its test and spines have been found in the localities enumerated above.

CIDARIS SUBVESICULOSA, *d'Orbigny*. Pl. VIII, figs. 2, 4, 5, 6.

CIDARES PAPILLATÆ,	*Parkinson.* Organic Remains, vol. iii, p. 39, pl. iv, fig. 3, 1811.
CIDARIS CRETOSA,	*Mantell.* Geol. of Sussex, Trans. Geol. Soc., vol. iii, p. 205, 1835.
— PAPILLATA,	*Mantell.* Geol. of Sussex, p. 194, pl. xvii, fig. 13, 1822.
— CRETOSA,	*Morris.* Catal. of British Fossils, p. 50, 1843.
— VESICULOSA,	*Morris.* Ibid., p. 51, 1843.
— PAPILLATA,	*Reuss.* Die Versteinerungen der Böhmischen Kreideformation, p. 57, pl. xx, fig. 22, 1846.
— CRETOSA,	*Graves.* Essai sur la Topog. Géog. du Département de l'Oise, p. 688, 1847.
— —	*Bronn.* Index Palæontologicus, p. 298, 1848.
— SUBVESICULOSA,	*d'Orbigny.* Prod. de Paléontol. Strat., t. ii, p. 274, 1850.
— OVATA,	*Sorignet.* Ours. Foss. de l'Eure, p. 9, 1850.
— AMBIGUA,	*Sorignet.* Ibid., p. 10, 1850.
— VESICULOSA,	*Forbes,* in Dixon's Geol. of Sussex, p. 338, pl. xxv, figs. 1—4, 1850.
— —	*Quenstedt.* Handbuch der Petrefactenkunde, p. 375, pl. xlviii, fig. 49, 1854.
— —	*Forbes,* in Morris's Catalogue of British Fossils, 2nd ed., p. 75, 1854.
— SUBVESICULOSA,	*Desor.* Synopsis des Échinides Foss., p. 13, pl. v, fig. 27, 1855.
— GRANULO-STRIATA,	*Desor.* Ibid., p. 14, pl. v, fig. 26, 1855.
— OVATA,	*Desor.* Ibid., p. 14.
— AMBIGUA,	*Desor.* Ibid., p. 15.

CIDARIS SUBVESICULOSA, *Coquand.* Bull. Soc. Géol. de France, 2e serie, tom. xvi, p. 1013, 1860.

— — *Cotteau et Triger.* Échin. du dép. de la Sarthe, p. 250, pl. xli, figs. 1—9, 1860.

— — *Cotteau.* Paléontologie Française, Ter. Crétacé, tome vi, p. 257, Pls. 1059—1061, 1863.

Test large, circular, inflated, nearly equally depressed at both poles; ambulacral areas slightly flexed, wide, with six rows of nearly equal-sized granules at the equator, diminishing to four and two rows at the poles, the external series being the largest and most persistent; poriferous zones narrow, depressed, and composed of simple oval pores, separated from each other by an elevation of the septum; inter-ambulacral areas wide, six or seven large plates in a column; the three equatorial plates with large areolæ, those near the peristome small, and the two upper plates near the disc with small rudimentary tubercles; areolæ circular, depressed, surrounded by a ring of mammallated granules, boss flat, with a smooth summit, tubercle moderate and perforated; miliary zone wide, filled with fine close-set homogeneous granules, disposed in very regular horizontal lines, radiating from the scrobicular circle to the border of the plates; peristome small and pentagonal; apical disc large, ovarial plates wide, narrow, and perforated at a distance from the border; ocular plates heart-shaped, with marginal orbits. Two consecutive series of cuboidal anal plates arranged within the pentagonal area formed by the ovarials; vent small and sub-central.

Spines slender, elongated, and cylindrical; surface covered with longitudinal elevations, having a fine serrated or spinous border gradually becoming attenuated towards the base; neck short, with longitudinal lines; milled ring prominent, articular surface without crenulations.

Dimensions.—Specimen fig. 5—height, one inch and one tenth; transverse diameter, one inch and seven tenths.

Description.—This urchin has been mistaken for *Cidaris vesiculosa,* Goldf., from which it differs, however, in many important characters; these have already been indicated in the description of that species (p. 41). The test is in general of moderate size, and nearly equally depressed at both poles; the ambulacral areas are slightly flexed, with six rows of granules at the equator; the external rows have larger mammillated granules than the inner rows, which gradually disappear as the area becomes narrower near the peristome and disc; the poriferous zones are narrow, depressed, and sub-flexuous; the pores are oval, and oblique as they approach the disc, and the septa have small elevated granules between the holes. The inter-ambulacral areas are large, the plates wide and deep, six or seven in a column (Pl. VIII, figs. 4, 5), the areolas are circular and moderately depressed; they are widely spaced out at the upper surface, and placed closer together at the infra-

marginal region and near the peristome; the margin is surrounded by a complete circle of large mammillated granules raised on shield-like plates. On the two uppermost plates of each column the areolæ are very narrow, or altogether obsolete (fig. 4, *a*). The boss has a flat smooth summit (fig. 1, *c*), and the large tubercle is deeply perforated (fig. 1, *c* and *d*). The miliary zone is very wide at the equator, and becomes narrower near the peristome and the disc. It is more or less depressed in the middle, along the line of the sutures, and covered with fine homogeneous granules set closely together; the granules are arranged in regular horizontal lines (fig. 1, *c*, *d*, *e*), which radiate from the circumference of the areolæ to the border of the plate.

The apical disc is large and pentagonal (fig. 4, *a*, *b*), and well preserved *in situ* in the fine specimen, fig. 4, *a*. The five large ovarial plates have an irregular rhomboidal form, with the ductal holes near the border; the oculars are heart-shaped, and have marginal orbits; the anal plates form a double series within the discal circle, and the vent (fig. 4, *b*) is a small excentral aperture with a third series of small plates on its anterior part only. All the elements of the disc are closely covered with the same style of granules that fill the miliary zone.

The peristome, smaller than the discal opening, is of a pentagonal form; in none of our specimens are the dental pyramids preserved.

The spines are long, slender, cylindrical, with longitudinal ribs having a spinous border (fig. 2, *a*, *b*); the valleys between the elevations have a finely chagreened surface; the neck is short and striated, the head moderately large, and the milled ring prominent (fig. 2, *c*). The acetabulum has a smooth rim. One spine must have measured $2\frac{3}{4}$ inches in length. The large mammillated granules surrounding the areolæ supported small, flat, triangular spines (fig. 6), having their surface ornamented with longitudinal microscopic lines, and articulated to the tubercle by a semicircular depression at the base. I have figured one of these scrobicular spines at fig. 6, where the line shows the natural size, and the figure is enlarged four diameters.

Affinities and differences.—This species has long been considered to be the *Cidaris vesiculosa*, Goldf., but is distinguished from that urchin in having the ambulacra less flexed, a greater number of plates in the inter-ambulacral columns, the upper tubercles of both series rudimentary, and in having the granules in the miliary zone arranged in horizontal rows. *Cidaris vesiculosa*, Goldf., has a smaller test, the ambulacra much more flexed, the plates in a column fewer, the tubercles consequently wider apart, the upper tubercles largely developed, and the granules in the miliary zone not arranged in horizontal rows. The spines in *C. subvesiculosa* are long, slender, and tapering; those in *C. vesiculosa* are shorter and thicker. This urchin so closely resembles *C. perlata*, Sorignet, and *C. Vendocinensis*, Ag., that they appear to me to be only varieties of *C. subvesiculosa*, d'Orbig.; the spines of the latter likewise closely resemble those attributed to *C. serrata*, Desor. It is possible that if a collection of good type-specimens of these different reputed

species were compared with each other, they would be found to be only so many cognate varieties of one form.

Locality and Stratigraphical position.—This species is found in the Upper Chalk of Kent, Sussex, and Wilts.

In France M. Cotteau gives the following localities in which it is very common in the Étages Turonien et Sénonien: Bolbec (Seine-Inférieure); Houguemarre, Vernonnet, Petit-Andelys (Eure); Notre-Dame-du-Thil, Tartigny (Oise); la Faloise (Somme); Saint-Fraimbault, Marçon, les Menus (Sarthe); Villedieu, Villiers (Loir-et-Cher); Semblancay, Limeray (Indre-et-Loire); Briolay (Maine-et-Loire); Barbezieux, Aubeterre, Lavalette, Salles (Charente); Royan, Saint-Georges Talmont, Saintes, Cognac (Charente-Inférieure); Perigueux, Trétissac, Neuvic (Dordogne); Bugarach, Soulatge (Aude).

History.—This urchin was first figured by Parkinson in 1811. The test and spines are sufficiently well drawn, in the absence of a description, to enable us to identify the species. In 1822 Mantell described, under the name *C. cretosa*, a Cidaris represented by Parkinson ('Organic Remains,' Vol. III, Pl. I, fig. 11), and united to fig. 3, Pl. IV, of the same work, which served as the type of *C. subvesiculosa*. Professor Forbes identified this species with the *C. vesiculosa*, Goldf., and figured it under that name in Dixon's 'Geology of Sussex.' In 1850 M. d'Orbigny, in his 'Prodrome de Paléontologie,' separated it from that form under the name *subvesiculosa*, which has been adopted by MM. Desor, Cotteau, and other authors.

Cidaris Merceyi, *Cotteau.* Pl. VIII, figs. 1, 2, 3.

Cidaris Merceyi, *Cotteau.* Paléont. Française, Ter. Crétacé Échinodermes, tom. vii, p. 281, pl. 1068, 1862.

Test large, circular, and elevated above, inflated and depressed below; ambulacra narrow, depressed, and slightly flexed; two rows of small regular mammillated granules on the external border, and four rows of smaller, irregular granules on the central portion of the area; poriferous zones narrow, flexed, composed of round pores in oblique pairs; inter-ambulacra wide, six or seven large plates in a column; tubercles well developed at the base and equator, but small and obsolete on the upper surface; areolæ circular, depressed, margin surmounted by a circle of regular mammillated granules.

Dimensions.—Height, two inches; transverse diameter, two and a half inches.

Description.—This remarkable urchin, which appears to be an elevated variety of *Cidaris subvesiculosa*, has been described by M. Cotteau as a distinct species under the

name *C. Merceyi*. The test is large and circular, elevated at the upper surface, inflated at the equator, and flat at the base (fig. 1, *a*, *b*). The ambulacral areas are narrow and slightly flexed, much depressed at the medium suture, and furnished at the widest part with six rows of granules. The two marginal rows have larger granules, very regular in size and arrangement, and raised on small plates (fig. 1, *c*); the four inner zones are much smaller and less regular (fig. 1, *c*); the poriferous zones are narrow, deeply sunk, and slightly bent; the small round pores are disposed in oblique pairs, of which there are twenty-one, opposite one large equatorial plate (fig. 1, *c*).

The inter-ambulacral areas are wide and largely developed; there are from six to seven plates in each column, of which the four or five lower plates have large areolæ, with moderately sized tubercles; the two uppermost plates are destitute of areolæ, and have small rudimentary tubercles (fig. 1, *a* and *b*). The areolæ at the base and equator are narrow and deeply depressed, well spaced out from each other at the equator, and set closer together at the base. The scrobicular margin of one of the equatorial plates is surrounded by a circle of eighteen regular mammillated granules, larger than those filling the miliary zone (fig. 1, *c*); the boss is prominent, the summit smooth, and the tubercle moderately large and widely perforated (fig. 1, *d*). Above the equator the two or three upper tubercles entirely change their character, the areolæ become extremely narrow or disappear (fig. 1, *b*), and the tubercle becomes a mere rudiment in the midst of the miliary granulation. The plate of this series nearest the equator, the third from the discal end, supports a very narrow areola (fig. 1, *e*) with a small tubercle, and on the two uppermost plates the tubercles are mere warty rudiments surrounded by granules.

The inter-ambulacral plates are large, convex, and inflated (fig. 1, *c*, *d*, *e*) towards the middle, and slope gently towards the sutures, which are very well marked in this species.

The miliary zone is wide and well developed, depressed in the middle and between the plates; the granules are fine, abundant, and homogeneous, and arranged in regular lines that radiate horizontally from the areolæ to the borders of the plate (fig. 1, *c*, *d*, *e*), resembling in this respect *C. subvesiculosa*.

The mouth-opening is small, and the peristome pentagonal; the upper surface of the test is fractured, and the disc absent. M. Cotteau, who has figured a very complete specimen of this *Cidaris*, says that the periproct is pentagonal and star-shaped, and the disc solid and inflated, and larger than the peristome; the ovarial plates are thick and angular, their internal surface smooth and marked by three facettes for articulation with the external row of anal plates; the ocular plates are small, subpentagonal, deeper than wide, and not notched at the summit of the ambulacra.

The spines have not been found in relation with the test.

Affinities and differences.—This species resembles in so many important particulars the preceding species, that I hitherto considered it to be a conoidal variety of that form.

M. Cotteau says this is one of the most curious species of Cidaris. Its form is in

general inflated and sub-conical, its superior inter-ambulacral plates are entirely deprived of tubercles, the structure of its periproct and apical disc impart a peculiar physiognomy to it, and clearly distinguish it from its congeners. It is distinguished from *C. subvesiculosa* by its greater size, its inflated sub-conoidal form, its straighter ambulacra, and smaller and less regular granules. Its inter-ambulacral plates are more numerous, and the three uppermost plates in each column are entirely deprived of tubercles in the specimen figured by M. Cotteau, and they are small and rudimentary in the urchin figured in our Pl. VIII, fig. 2.

Locality and Stratigraphical position.—Collected from the White Chalk, where it is very rare. The fine specimen figured by Mr. Bone belongs to Dr. Bowerbank's collection. That figured by M. Humbert for M. Cotteau was collected at La Faloise près Breteuil (Somme); in the Étage Sénonien, where it is very rare. It belongs to M. Tombeck's collection.

Cidaris perornata, *Forbes*, 1850. Pl. VII *a*, fig. 2.

Cidaris perornata, *Forbes*, in Dixon's Geol. of Sussex, p. 339, pl. xxv, fig. 8. 1850.
— longispinosa, *Sorignet*. Ours. Foss. de l'Eure, p. 19, 1850.
— Sarthacensis, *d'Orbigny*. Prod. de Pal. Strat., t. ii, p. 274, 1850.
— perornata, *Forbes*, in Morris's Catal. of Brit. Fossils, 2nd edit., p. 74, 1854.
— — *Cotteau*. Paléontologie Française, t. vii, p. 274, pl. 1065, figs. 3—14, 1862.

Test elevated, melon-shaped. Ambulacra nearly straight, narrow, depressed. Six rows of small granules, the marginal the largest and most regular, the inner small, with intermediate smaller ones. Inter-ambulacra wide, seven or eight large plates in each column; areolæ wide, circular, with a marginal circle of very small granules; boss smooth or slightly crenulated; tubercles small and perforate; sutures well marked, depressed. Spines long, cylindrical, several-ridged; ridges irregular towards the base, and serrated, the interstices granulated.

Dimensions.—Height, one inch and eight tenths; transverse diameter, two inches.

Description.—The test of this fine urchin is high and melon-shaped, and reminds me of *C. maximus*, from the Coral-rag of Germany. The ambulacral areas are narrow,

nearly straight, and provided with six rows of small granules; the marginal series are the largest, the inner ones are small, and between them are some still smaller granulets scattered about the area. The poriferous zones are only gently waved, the holes round, and placed transversely; there are fifteen pairs opposite each of the equatorial plates. The inter-ambulacral areas are very regularly formed; the plates, about eight in each column, are large and uniform; the areolæ are wide and circular, and occupy the entire depth of the plate; the margin is surrounded by a circle of very small mammillated granules, about twenty-one in number, and well spaced out from each other; the boss is not prominent, and only some of the summits are feebly crenulated, whilst the others are smooth. The tubercle is small, and deeply perforated (fig. 2, *a*, *b*). The miliary zone is wide, and depressed in the middle; the granules are fine, homogeneous, and nearly equal-sized, and arranged in regular horizontal rows, which follow the angles of the median sutures. As the areolæ occupy the centre of the plates, there is a considerable granular space between the ambulacral side of the areolæ and the poriferous zones. The sutures are all very distinctly marked, and the median inter-ambulacral is much depressed. The peristome is sub-pentagonal and large. The spines are long, cylindrical, and sub-acuminated at the summit (fig. 4, *a*). The stems are provided with long, narrow spines, projecting at intervals from many regular, longitudinal ridges, and having the interstices finely granulated (fig. 4, *c*). For the most part these spines are equally and uniformly disposed; sometimes, however, they lose their homogeneity, and vary in their height and in preserving a longitudinal disposition. The valleys between the ridges on the stem are throughout covered with fine, delicate, microscopic, sub-granular, longitudinal striæ, which are only visible by the aid of a lens (fig. 4, *c*). The neck is without ridges and spines; the collar is long and finely striated, and separated from the stem by a distinct line (fig. 4, *b*). The head is large, the milled ring prominent, with thicker striæ than those on the collar, and the rim of the acetabulum is smooth (fig. 4, *b*).

Affinities and differences.—The melon-shaped test, very regular inter-ambulacral areas, areolæ and tubercles gradually increasing from the base to the upper surface, added to the long, slender spines, with prickly ridges, serve to distinguish this species from its congeners of the White Chalk. The spines resemble those attributed to *C. spinigera*, Cott., of the Neocomian stage, from the middle of France, but they manifest differences which are sufficiently distinctive of each. In *C. perornata* the spines arise from ridges at regular intervals, which are absent in *C. spinigera*.

Locality and Stratigraphical position.—This species was collected from the White Chalk of Kent and Sussex. The specimens figured are from the cabinets of Dr. Bowerbank and Rev. T. Wiltshire.

The foreign localities of this urchin are, according to M. Cotteau, Vernonnet, Giverney, Pinterville, Houguemarre (Eure), Épagny (Somme), Tartigny (Oise), La Flèche, (Sarthe); where the spines are common in the Étage Sénonien.

History.—The late Frederick Dixon, Esq., F.G.S., and Professor Forbes, first figured, in 1850, the test and spines of this species from the White Chalk of Sussex, and the latter described it as a new species under the name *C. perornata.* M. l'Abbé Sorignet described the spines which he collected in the department of the Eure under the name *C. longispinosa*, and Professor d'Orbigny those found in the Sarthe as *C. Sarthacensis.* As Professor Forbes first figured and described the urchin, and the other authors only described it, the name of the figured specimen is for this reason retained.

CIDARIS HIRUDO, *Sorignet*, 1850. Pl. X, figs. 1—5 ; Pl. IX.

CIDARIS	HIRUDO,	*Sorignet.* Ours. Foss. de l'Eure, p. 17, 1850.
—	SCEPTRIFERA,	*Forbes*, in Dixon's Geol. of Sussex, p. 338, pl. xxv, figs. 32 and 33,
—	—	var. SPINIS TRUNCATIS. 1850.
—	SULCATA,	*Forbes*, in Morris's Catal. of Brit. Fossils, 2nd edit., p. 75, 1854.
—	—	*Woodward.* Mem. of Geol. Surv., Decade v, explanation of pl. v, p. 3, 1856.
—	HIRUDO,	*Cotteau.* Paléontologie Française, tom. vii, p. 244, pl. 1054, figs. 6—16.

Test, in general, of moderate size, sometimes large, slightly depressed equally at both poles ; ambulacral areas narrow, flexed, with six rows of granules at the equator, diminishing to two at the apertures ; in the two external rows the granules are larger and mammillated, in the inner rows they are very regularly disposed, but smaller and unequal ; poriferous zones very narrow, depressed, and flexed, and formed of small round pores, the intervening septum having a slight divisional elevation ; inter-ambulacral areas wide ; columns with five or six large plates; areola moderate, depressed, margin elevated, and surrounded by a circle of mammillated granules, well spaced out apart ; boss with a smooth summit ; tubercle moderate in size and perforated, the areolæ and tubercles increasing gradually in magnitude from the peristome to the upper part of the columns ; miliary zone depressed in the middle, and filled with equal-sized granules ; line of the sutures well marked throughout.

Spines elongated, cylindrical, subfusiform ; stem enlarged at the middle, and tapering at the upper third, summit truncated and presenting a stellate figure ; the longitudinal ridges on the stem have a granuliform structure, and the intervening valleys are finely chagreened ; the neck is short, distinctly defined, and marked with longitudinal microscopic lines ; the head is small, the milled ring prominent, and the acetabulum has a smooth ring around the brim.

Dimensions.—Specimen Pl. X, fig. 2—height, nine tenths of an inch ; transverse diameter, one inch and four tenths. Specimen Pl. IX—height, one inch and three tenths ; transverse diameter, one inch and nine tenths (?).

THE

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A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART SECOND.

ON THE CIDARIDÆ AND DIADEMADÆ.

PAGES 65—112; PLATES IX, X, XII—XXI, XXI A, XXI B.

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Description.—This beautiful *Cidaris*, formerly identified by Professor E. Forbes as a variety of *C. sceptrifera*, and afterwards catalogued by him as a distinct species, under the name *C. sulcata*, had been previously considered by the Abbé Sorignet, from its spines alone, as a new form, and described in 1850 as *C. hirudo* in his work on the 'Oursins fossiles du département de l'Eure,' and this name has the priority.

The test of the fine specimen belonging to Henry Willett, Esq., F.G.S., and fully illustrated in Pl. IX., fig. 1 *a*, *b*, *c*, attains a moderate size, is inflated at the equator, and equally flattened at the poles. The ambulacral areas are narrow, sinuous, and band-like, forming prominent, well-marked segments in the test, filled with small, close-set, regularly arranged rows of granules; there are six rows at the equator, four rows in the upper and lower thirds, and two rows only near the discal and oral apertures. The most prominent granules are in the external rows; they are slightly mammillated and extend throughout the entire area. Pl. IX, fig. 2 *b*, is an equatorial inter-ambulacral plate, with the ambulacral area attached, magnified three diameters. In the second row the granules are nearly as large, and extend through eight tenths of the area; the third rows extend through the height of two large plates; the granules are set very closely together, and regularly arranged in transverse rows. The poriferous zones are narrow, depressed and flexuous, fig. 2 *b*; the pores are small and round, and the septum supports a small round granule; the entire series of septal granules forms a moniliform line between the pores, which gives an apparent lateral extension to the width of the area; and opposite one of the large plates there are twenty-three pairs of pores.

The inter-ambulacral areas are wide, the plates composing them being deep and broad, five or six in each column; the areolas are circular and moderately depressed; they are closely approximated on the under side, wider apart at the equator, and still further apart above.

Pl. IX, figs. 1 and 2, Pl. X, figs. 1, 2, 3, show the character of the areolæ; the margin is slightly elevated (Pl. IX, fig. 2 *b*) and encircled by a row of larger mammillated granules; the uppermost plate in each alternate column has a rudimentary wart-like tubercle without areola (Pl. IX, fig. 1 *a*, *b*); and in the other column the tubercle is small, but complete, and surrounded by a narrow shallow areola (fig. 1 *a*, *b*); the base has a smooth flat summit, with only rare indications of crenulations; those in fig. 2 *b*, are strongly drawn: the tubercle is large and perforated. The miliary zone is wide, depressed along the middle of the area, and along the transverse lines of the sutures: the granulations on the surface of the plates are large in size and uniform in arrangement thereon.

The apical disc (Pl. IX, fig. 2 *a*) is large, and composed of five ovarial and five ocular plates; the rhomboidal ovarials are widely perforated, and the cordate oculars have small marginal orbits in the disc (fig. 2 *c*); the aperture is pentagonal, and there are indications of the outer series of small anal plates.

The mouth-opening (Pl. IX, fig. 3, and Pl. X, figs. 1 *a*, and 3 *b*) is small, and the peristome slightly pentagonal; in Pl. IX, fig. 3, there is a rudiment of a jaw and tooth.

The spines exhibit a considerable variation of form; in some they are elongated and cylindrical, as in Pl. IX, fig. 1 *b;* or elongated and subfusiform, as in fig. 5, and Pl. X, fig. 1 *b*, and figs. 5, 6. In all the stem is slightly enlarged in the middle, and tapers towards the upper third. The surface in some specimens is sculptured with fine longitudinal lines, as in Pl. IX, fig. 1, and Pl. X, figs. 1, 4, 6; or has granulated ridges with intervening valleys, as in Pl. IX, fig. 5, and Pl. X, fig. 5. The summit is truncated more or less in all the specimens, and exhibits a stellate figure with several central convexities as in Pl. IX, figs. 4 *a*, and 4 *c*, 5, the radii being formed by the development of the longitudinal ridges.

In the more finely sculptured spines the longitudinal lines on the stem have a granuliform structure; the intervening valleys are finely shagreened throughout, and provided with delicate subgranular striæ. The neck is short, distinctly defined, with a finely sculptured line above the ring (Pl. IX, figs. 4, 5, Pl. X, figs. 1, 4, 6).

The milled ring is moderately prominent, with coarser lines than those on the neck; the articular cavity is smooth, or has some feeble crenulations on its margin (Pl. IX, figs. 4, 5, Pl. X, figs. 1, 4, 6).

Affinities and Differences.—This form has long been considered to be a mere variety of *C. sceptrifera;* the proximal discal plate, however, has generally a rudimentary tubercle of larger size and rounder shape than that found on *C. sceptrifera.* The second discal plate (counting downwards) has the upper three quarters of the boss much more strongly crenulated than in the other species (at p. 64 the upper bosses of *C. hirudo* were accidentally stated to be not crenulated). The large size of the areolas, their comparative continuity, the prominent mammillated granules upon their circumference, and the circumstance of the highest areola bearing a perfect tubercle being distant from the anal margin by not more than half its diameter, easily separate this species from *C. sceptrifera,* in which the areolas have more sloping borders, smaller and more numerous mammillated granules, and in which the highest areola bearing a perfect tubercle is generally distant from the anal margin by the length of its diameter. The spines are much shorter and more uniform in diameter than in *C. sceptrifera,* having their greatest swelling midway between the acetabulum and summit, instead of towards the former; their extremities are more truncated, often becoming stellate, as on Plate IX. fig. 4 *c;* their surface is covered with longitudinal ridges, armed with very much shorter spiny projections, often almost obliterated; the collar is shorter, and the acetabulum is marked with stronger crenulations. *C. hirudo* is a rather small species, less than *C. sceptrifera,* and not so common. An average size will be about one inch and one tenth in transverse diameter, height six tenths, length of spine one inch, greatest diameter of spine three twentieths.

Locality and Stratigraphical Position.—The specimens I have examined have been collected from the White Chalk of Sussex and Gravesend. In France M. Cotteau gives the following localities where this Urchin is common—the Étage Cénomanien, de Havre

(Seine-Inférieure), Fourneaux la Madeleine (Eure), Saint-Parres près Troyes (Aube), Étage Sénonien Inférieure, Etretat (Seine Inférieure), Tartigny (Oise), Châlons-sur-Marne (Marne).

History.—The Abbé Sorignet in 1850 described a spine of this species under the name *C. hirudo.* The same year the test was well figured with its spines attached by the late Mr. F. Dixon, and described by the late Professor Forbes as *C. sceptrifera* var. *spinis truncatis;* subsequently it was found that Mr. Dixon had given it the MS. name *C. sulcata,* under which name it appeared in the second edition of the 'Catalogue of British Fossils,' and in Dr. Woodward's notes on Cidaris in the Fifth Decade of the 'Memoirs of the Geological Survey.' The Abbé Sorignet's name has been properly retained by M. Cotteau in his continuation of D'Orbigny's Paléontologie Française.

CIDARIS DIXONI, *Cotteau.* Pl. XI, fig. 4; Pl. XII, fig. 6.

CIDARIS. *Dixon,* Geol. of Sussex, p. 339, pl. xxiv, fig. 25, 1850.
CIDARIS DIXONI, *Cotteau.* Paléontologie Française, tom. vii, p. 238, pl. 1051, fig. 78, 1862.

The test of this fine Urchin is unknown.

Description.—Spine very large; stem thick, oblong, glandiform, much enlarged in the middle, and tapering towards the neck and apex; the lower part is covered with convex, scale-like plates, arranged without much regularity; in the middle part they are larger, and have much the same character; at the upper third they are less closely set together, become ridged, and form granulated lines, which pass towards the summit; the intervening valleys are covered with fine longitudinal lines.

The neck is short and smooth, although there are traces of longitudinal lines; the milled ring is not prominent, and the articular cavity indicates a small tubercle; the rim of the acetabulum is smooth.

Dimensions.—Length of the entire spine, from acetabulum to apex, $1\frac{7}{10}$ths of an inch; length of neck and head $\frac{3}{10}$ths of an inch; length of stem $1\frac{1}{10}$ths of an inch; thickness of stem, at widest part, $\frac{8}{10}$ths of an inch.

Locality and Stratigraphical Position.—Found in the Grey Chalk near Folkestone by the Rev. T. Wiltshire, F.G.S., whose cabinet contains a very fine specimen. Mr. Dixon's type, which formed the subject of fig. 4, Pl. XI, is in the collection of Henry Willett, Esq., F.G.S. M. Cotteau records two specimens from the Étage Cénomanien, at Havre (Seine Inférieure), where it is very rare.

CIDARIS PLERACANTHA, *Agassiz.* Pl. XI, fig. 5; Pl. XII, fig. 5.

CIDARIS PLERACANTHA, *Agassiz.* Catal. Syst. Ectyp. Foss., p. 10, 1840.
— — *Sorignet.* Oursins foss. de l'Eure, p. 4, 1850.

Cidaris pleracantha, *D'Orbigny*. Prodrome de Pal. Strat., t. ii, p. 274, Ét. 22, 1850.
— — *Dixon*. Geology of Sussex, tab. xxiv, fig. 23, 1850.
— — *Desor*. Synopsis des Échinides foss., t. vi, fig. 7—10, p. 14, 1855.
— — *Woodward*. Mem. Geol. Surv. Decade V, Expl., pl. v, p. 3, 1856.
— — *Cotteau*. Paléontologie Franç., Ter. Crét., tom. vii, tab. 1075, fig. 1—13, p. 310, 1865.

Test unknown.

Description.—Spine very large, inflated, pyriform, with an obtuse and unequally rounded summit; stem ornamented with longitudinal striæ, very fine or subgranular, and visible near the lower part, the upper part is smooth; the stem suddenly contracts to form a very short neck and a small head; milled ring a little elevated and marked by fine lines; acetabulum small with a smooth ring.

Spines of this species are very rare indeed in the English Cretaceous rocks. The specimens collected at Meudon, near Paris, and at Civières (Eure), vary much in form and dimensions; some are short, thick, or pyriform, and have the stem round or depressed at the summit, or inflated, subcylindrical, accuminated, or truncated; and in a large specimen before me from France the stem is bifurcated.

Locality and Stratigraphical Position.—Mr. Dixon's specimens were said to have been found in the Grey Chalk of Sussex. It occurs also in the Lower Chalk of Dorking. The specimen figured, Plate XII, fig. 5, in the Cabinet of J. R. Capron, Esq., F.G.S., came from that locality.

Cidaris Farringdonensis, *Wright*. Pl. II, figs. 6, 7, and 8 *a*, *b*, *c*.

Test known only by isolated plates.

Description.—Spines long, slender; lower portion of the stem smooth, upper portion ornamented with longitudinal rows of granules forming tuberculated lines or ridges in different spines, and terminating in a star-shaped summit at the apex. The proportional length of the smooth to the granulated ornamentation of the stem varies in different spines —in some with a long smooth portion the line of separation is defined by an annular elevation, in others with a shorter smooth portion the granulations arise without any such ridge. The valleys between the longitudinal ridges have a finely shagreened surface; the head is moderate in size, the milled ring prominent, and the small acetabulum has a well-defined marginal rim.

The isolated plates of the test are much worn by friction; the primary tubercle is small, the areola wide and smooth, and the margin surrounded by a circle of large well-defined granules, resembling the plates of *Cidaris vesiculosa*.

Affinities and Differences.—The spines of *Cidaris Farringdonensis* differ so much from

all other forms at present known that they cannot be mistaken for any other species, the long smooth lower portion of the stem forming such a conspicuous specific character of this spine.

Stratigraphical Position.—The specimens I have figured were collected from the Sponge-gravel near Farringdon, in Berkshire, associated with *Pseudodiadema rotulare*, Ag., *Hyposalenia Wrightii*, Desor, *Hyposalenia Lardyi*, Desor, *Salenia areolata*, Wahlb., and two new species of *Echinobrissus*, together with the Amorphozoa and Mollusca that characterise this remarkable formation.

My kind friend the Rev. T. Wiltshire, F.G.S., at my request, has contributed the following additional notes on some rare tests and spines of *Cidares* in his collection. These are figured in Pls. XII and XIII.

"In the course of last year you expressed the desire that I should send you some notes in reference to the fossils figured in Plates XII and XIII of your Monograph on the Cretaceous Echinodermata. In compliance, therefore, with your wish, the following remarks are forwarded, to be used or rejected as may seem most fitting.

"The Urchin drawn in figure 1, Plate XII, is probably a new species intermediate between *Cidaris sceptrifera* and *C. subvesiculosa*. I would suggest it should be named *C. intermedia*; it may be thus defined:—

Cidaris intermedia, *Wiltshire*. Pl. XII, figs. 1 *a*, 1 *b*.

"Test moderately large, inflated; ambulacral areas narrow, depressed, flexuous, with six rows of granules in the middle, the outer two the largest, diminishing to four rows above and below; poriferous zones winding, narrow, depressed, at the ambitus about the same width as the semi-ambulacral areas, narrower above, wider below; interambulacral areas wide, plates large, five in a column; areolas proximate, deep, suboval, with an elevated slightly overhanging scrobicular margin, encircled by a series of small granules, equal in dimensions to those of the outer row of the ambulacral areas, bosses not prominent, summit smooth, tubercle moderate in size, perforated; proximal discal plate in each column with a rudimentary tubercle, in a circular area; miliary zone narrow, filled with small equal-sized granules depressed along the line of sutures; apical disc wide, of the same diameter as the peristome; ovarial plates thick; jaws stout, triangular; spines long, slender, cylindrical, slightly tapering, surface marked by regular longitudinal rows of spiny projecting granules, the intervening space finely shagreened.

"*Dimensions.*—Height $\frac{7}{10}$ths of an inch (the specimen being very slightly crushed); transverse diameter 1 inch and $\frac{6}{10}$ths.

"*Description.*—The test of this Urchin is circular, and is equally depressed at both

poles; the ambulacral areas are narrow and flexuous, rather more so than in *C. sceptrifera*, rather less so than in *C. subvesiculosa;* granules six in number at the ambitus, diminishing to four at the poles; the central rows at the upper and under surfaces minute and irregular; the four central rows at the ambitus composed of granules of less size than those of the exterior rows, consisting of greater numbers, and somewhat irregularly arranged; the poriferous zones are narrow and depressed, and follow the flexures of the areas; the pores are round, closely situated, and disposed obliquely; there are eighteen pores (thirty-six in all) opposite one of the largest plates; the interambulacral areas are very wide, five to six plates in a column; the areolas are wide, slightly oval (the minor axes being towards the poles) at the ambitus, circular at the peristome and anal margins, and are surrounded by an undercut overhanging border, encircled by a series of about twenty granules, each raised on a distinct shield-like mammillated plate; the areolas at the equator have their borders separated from the upper and under plates by a small interval occupied by about five sets of granules; at the under surface these granules are absent, and the scrobicular margins are in contact; at the upper surface the granules increase in number; the penultimate plate of the anal surface has an areola rather larger than that below; the final plate has a rudimentary tubercle in a small circular areola, this last plate is covered with granules; the boss is not prominent, its summit is smooth and without crenulation, the tubercle is moderately large and perforated; the miliary zone is narrow, and the granules are so arranged as to present the appearance of radiating from the scrobicular margin towards the sutures; they are much smaller than those surrounding the areolas; the surface on which they are studded dips towards the sutures, causing the latter to be clearly defined. The apical disc is of the same size as the mouth-opening and in the specimen figured is six tenths of an inch in diameter; the plates with which it is furnished are large, and covered with granules; the mouth is furnished with strong jaws, shown in the plate.

"The spines are long, cylindrical, and very slightly tapering, covered with small, strong, equal-sized granules, the points of which project outwards. They are arranged in ten regular longitudinal ridges, with a sulcus between them covered with a very fine granulation. The spiny granules continue to within a tenth of an inch of the collar; the neck is very short and smooth, the head moderately large, cone-shaped, and longitudinally striated with numerous fine lines; the rim of the acetabulum is very finely crenulated. The length of the longest spine, that of the ambitus, is one inch and eight tenths; it is slightly broken at the extremity, and therefore would, if perfect, be rather longer; its diameter is one tenth of an inch; the short spine, which is unbroken (seen in the right hand of the plate), has its extremity suddenly expanded.

"*Affinities and Differences.—Cidaris intermedia*, in the general appearance of its test, closely approaches *C. sceptrifera* and *C. subvesiculosa;* it differs from the former in the scrobicular margins from the ambitus to the peristome being in contact, or not separated by more than one granule,—in the more narrow miliary zone,—in the lesser number of rows

of granules in the ambulacral areas at the ambitus (*C. sceptrifera* in specimens of the same size as that under consideration having eight at the equator, whilst this species has six),—in these granules being more irregularly disposed and more crowded together,—in the proximal discal plate being marked with a more prominent tubercle, and in its shape being less elongated,—in the areolas being relatively larger,—in the spines being uniformly cylindrical instead of fusiform, and of much less diameter,—and in the serrated ridges of the spines being fewer, wider apart, and continuous the whole length, whilst in *C. sceptrifera* some of the ridges cease at the widest part of the spine. *C. intermedia* differs from *C. subvesiculosa* in the scrobicular margins of adjacent plates being less widely separate,—in the granules on the margins of the areolas being more distant,—in the sutures of the miliary zones being less marked,—in the miliary zones being smaller,—in the spines being of less diameter, with less numerous ridges, and apparently shorter (some spines of *C. subvesiculosa*, of a test of equal dimensions, reaching a length of three inches),—and in the plates presenting a flatter and less tumid appearance.

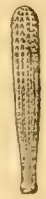
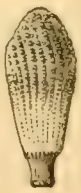
"*Locality and Stratigraphical Position.*—Collected from the White Chalk of Sussex, apparently from the base of the Chalk-with-flints; rare. The specimen figured, Plate XII, fig. 1 *a*, is of the natural size. Fig. 1 *b*, one of smaller spines magnified, length 1 inch, diameter $\frac{1}{10}$th of an inch.

"Additional Notes on *CIDARIS CLAVIGERA, König.* (See p. 48.)

"Very marked as are the variations in the general aspect of the spines of *C. clavigera*, it will usually be found that a single and prevailing form is connected with each individual test. On Pl. XIII are drawn the tests and spines (figs. 1 *a*, 3 *a*, 4 *a*) of three specimens, in which the spines attached to the tests are tolerably uniform in shape in each case collectively, yet are dissimilar when viewed by groups, those of fig. 1 *a* being all claviform, those of fig. 3 *a* being all medially constricted, those of fig. 4 *a* being all fusiform. The same remark holds good in other examples not drawn on the plate. I have now before me sixteen specimens of *C. clavigera*, with the spines attached, in all of which specimens, although as a general character each company of spines has a club-shaped or approximately club-shaped contour, there is so great a variableness among the different groups that if in any group the two extremes in form were to be compared apart from the test they could easily be mistaken for different and distinct species; some (No. 1 of the Table on page 72) being wholly cylindrical, these by easy gradations seen in sets of forms passing on so as to become pear-shaped (No. 4), next taking up the ordinary clavigerous type (Nos. 6, 7, 8), and ending with those having the medially constricted outline (No. 10).

"I append woodcuts of some of these varieties, giving their dimensions in tenths of an inch, and also the diameter (major axis) of the test to which they belong. The measurements of the spine in each case have been derived from a specimen which in its natural position would have been affixed to the ambitus.

"Table showing variation of form in the spines of *Cidaris clavigera*.

Ambitus Spine, characteristic of the general form of the whole of the spines attached to any individual test of *C. clavigera*, nat. size.	Total length of longest ambitus spine.	Diameter of spine at neck.	Diameter at greatest thickness.	Length of neck before swelling commences.	Form of apex.	Diameter of test at ambitus.
Almost uniformly cylindrical and slender; very unusual form of spine. 1. 	1·1	·1	·2	·3	Hemispherical.	Uncertain, about 1·0
Almost uniformly cylindrical, but not slender; very rare. 2.	1·2	·1	·3	·2	Hemispherical.	Uncertain.
Slightly tapering; rare. 3.	·8	·1	·2	·1	Subacute.	About ·6
Pear-shaped, longitudinal section elliptical; rather rare. 4. 	·9	·2	·4	·2	Subacute.	1·1
Pear-shaped, longitudinal section ovate; rather rare. 5.	·8	·2	·4	·3	Sub-hemispherical.	1·2

"Table showing variation of form in the spines of *Cidaris clavigera*—continued.

Ambitus Spine, characteristic of the general form of the whole of the spines attached to any individual test of *C. clavigera*, nat. size.	Total length of longest ambitus spine.	Diameter of spine at neck.	Diameter at greatest thickness.	Length of neck before swelling commences.	Form of apex.	Diameter of test at ambitus.
Club-shaped, stem slightly tapering; common. 6.	1·3	·2	·3	·6	Hemispherical.	About 1·6
Club-shaped, stem cylindrical; common. 7.	1·0	·2	·3	·6	Hemispherical.	1·1
Club-shaped, portion nearest the apex constricted; common. 8.	1·3	·1	·4	·7	Hemispherical.	1·1
Club-shaped, portion nearest the apex constricted; rather rare. 9.	1·0	·1	·2	·4	Hemispherical.	·8
Constricted at about half the length; very rare. 10.	·7	·1	·2	·1	Acute.	·6

"From the above Table it will be seen that this variation in form is independent of the size of the test, and is dependent rather upon some peculiar law in the formation of the spine, or some cause which has contributed to produce a greater development of calcareous matter in one part than in another. In flints which contain the spines of *C. clavigera* a fracture passing through the spine will often exhibit this growth very beautifully; thus, in the woodcuts (fig. 1), whilst an earlier form of the spine is clearly defined, the subsequent addition of material is also manifested by the change of tint. The same effect can also be observed in longitudinal sections of the ordinary spines, a difference of density and of hardness in the whole or parts of the enveloping layers being very apparent.

Fig. 1.

Sections of body-spines of *C. clavigera* in flint.

"In *C. clavigera* the difference between the spines of the peristome and of the ambitus is more marked than in most of the other species of the Cidaridæ of the Upper Cretaceous group. The woodcuts (fig. 2) drawn from the spines of the tubercles adjacent to the mouth, and magnified four diameters, show that their apex is more acute, their ridges fewer, and their body more elongate-ovate than in the larger spines of the ambitus. The spines of the granules (fig. 3) are also dissimilar, being longitudinally striated, contracted at intervals, having almost parallel sides, and being in transverse section ovate.

Fig. 2.

Spines of *C. clavigera* from the tubercles adjacent to the peristome; magnified four diameters. One spine has four serrated ridges, the other six.

Fig. 3.

Spine of *C. clavigera* from the granules on the margin of the ambulacral areas; magnified eight diameters.

"The spines in their original condition appear to have been tinted with parallel bands of colour, perpendicular to the axis. In several examples now in my cabinet the apex of the spine shows evidence of this peculiarity; but in one specimen in particular (a test to which the spines are attached) that circumstance is so marked and is so persistent (the base and apex of the body of the spines being specially affected) that it can hardly be the result of accident.

"The common longitudinal perforations in the outer layer of the spine alluded to at p. 50 seem to have been chiefly due to disease or to some difference in structure which caused those parts, now empty, to decay with greater facility in one direction than in

another. A transverse section of spines so affected proves that the canals are of neither uniform length nor dimensions, some being of greater extent and more open than others.

"The central perforation not unusual at the apex of some spines, seems also due to disease or to parasitic borings, and will often be found to extend downwards as far as the acetabulum. This is the case with the spine drawn in Pl. V, fig. 6. A portion of the surface of this spine having been carefully removed subsequent to the drawing being made on the plate, the cavity apparent at the apex was seen to extend through the whole length of the body, unaltered in size; just below this point it suddenly contracted in a circular curve (similar to the base of the perforations made by a *Pholas*) as though to avoid breaking through the walls of the neck; at the lower point of the circular excavation the opening appeared again, only with a very much less diameter, and extended as far as the articular cavity, through which it passed. Another spine open at the apex, when cut lengthways, gave the same result (of a continuous tube, of two different diameters), except that the opening, which extended almost as far as the acetabulum, did not pierce it, but passed outwards in a transverse direction.

"The test of *C. clavigera* varies in the proportions of its parts from youth to age; my smallest example, five tenths of an inch in width, differs considerably in appearance from my largest, which is one inch and seven tenths in width. Comparing these two it is seen that the tubercles in the former are relatively larger than in the latter; that the granules of the miliary zone are in the former almost as large as in the latter; that the number of plates are the same in both; that there is an oval rudimentary tubercle in the uppermost plate of the anal side in the largest specimen; that the areolas of the two superior tubercles of the anal side are in the smallest example separated by only three granules, including those of the scrobicular margin, whilst in the largest example there are fourteen. Both specimens have four rows of granules in the ambulacral areas at the ambitus; in the smallest they are of equal size and equally disposed, in the largest the two interior are much smaller than the two exterior, more numerous, and crowded together. These differences have a tendency to cause the two specimens, when placed with the anal side uppermost, to appear very dissimilar, particularly in the region of the miliary zone. Of these two specimens the smallest is much below and the largest much above the average size.

"Spines of *C. clavigera* are sometimes, but very rarely, found as far down as the middle of the flinty Chalk; the proper horizon of *C. clavigera* is above this part.

"Figures 1 *a*, 1 *b*, 2, 3 *a*, 3 *b*, 3 *c*, 4 *a*, 4 *b*, 5 *a*, 5 *b*, Pl. XIII, are from the Upper Chalk of Bromley, in Kent.

"Additional Note on *CIDARIS PERORNATA*, Forbes. (See p. 62.)

"This *Cidaris* is the largest of all the Cretaceous Cidaridæ; portions of a full-grown specimen now before me, containing four complete columns of plates in contact, give the following dimensions for the test—height, two inches and two tenths; transverse diameter, two inches and one tenth. The spines, like the body, also exceed those of all other species. In a mass of spines of *C. perornata* from my cabinet, which are all one tenth of an inch in diameter, is one which, although deficient of a portion of its apex, measures in the remaining part of its length four inches and six tenths—this length is by no means a maximum. The number of the plates and the form of the spines appear to have rendered perfect examples of the test with spines attached exceedingly rare. Separate plates and groups of broken spines are plentiful; complete columns of plates uncommon. Small *Ostreæ* are occasionally found affixed to the spines.

"The test, when full-grown, has, in the ambulacral areas, eight rows of granules at the ambitus; of which rows the two exterior are the largest and most evenly disposed, the six interior are more numerous, of less size, and not so regularly arranged; at the mouth-opening there are six rows, at the anal four; the second discal plate has nineteen pairs of pores in the poriferous zone; the proximal discal plate in each column has a rudimentary tubercle and an elongate obsolete areola. The granules of the miliary zone are of two sizes, the smallest of which occupy the spaces between the largest. In specimens of the test of the usual size the first, second, and third of the plates, reckoning downwards from the anal opening, have the upper half of the boss crenulated. The spines belonging to the granules of the scrobicular margins are flat and somewhat fan-shaped; they are covered with minute striæ, which converge from the circular base (in which there is an acetabulum) towards the smaller apex; length two tenths of an inch, greatest width one twentieth. The jaws of a full-grown specimen do not greatly differ in outline from those of other species; they are half an inch in length.

"*Cidaris perornata* is tolerably common in the Upper Chalk; it appears to commence (where it is rare) in the middle of the flinty Chalk.

"Additional Note on *CIDARIS DIXONI*, Cotteau. (See p. 67.)

"All the spines of this species hitherto found are of considerable size, and are claviform, and inflated; the apex is acute; the surface covered with numerous granules, which

are large and elongate on the upper half of the body, pointed at the apical region, circular on the lower half of the body, diminishing in area as they approach the neck, and ceasing at that part, arranged in rows gradually increasing in number from the apex to the greatest diameter, and afterwards more closely and less regularly deposited; the neck smooth, short, and very much contracted; the milled ring is slightly prominent, covered with fine longitudinal striæ; the head smooth.

"The spines of *C. Dixoni* occur at the base of the Lower or Grey Chalk in the cliffs between Folkestone and Dover, in the band containing the spinous *Ostrea carinata*, Sow. (M.C., tab. 365, fig. 1), in company with *C. Bowerbankii;* they are, however, very rare. The same species is found occasionally in the "Coprolitic Bed" of Cambridge, a deposit containing rolled fossils from the Lower Chalk, Upper Greensand, and Gault formations. The specimen figured in Pl. XII, fig. 6, and obtained from the Coprolitic Bed of Cambridge, is identical in all respects with the Folkestone examples, except that the surface is more worn, and appears to have been subjected to much friction; the width of the Cambridge specimen is seven tenths of an inch, length of body one inch. The total length of spine (measured from a specimen in perfect condition in my cabinet), from Folkstone is one inch and four tenths; greatest diameter (midway between apex and edge of acetabulum) seven tenths; length of head and neck three twentieths; diameter of neck three twentieths.

"The test of this *Cidaris* has not at present been discovered; it would appear, however, judging from the analogy of its spines with those of *C. Bowerbankii*, that it must have much in common with the latter, except size; perhaps it may be an aged form of *C. Bowerbankii*.

"Additional Note on *CIDARIS BOWERBANKII, Forbes.* (See p. 45.)

"In this species, as in others of the *Cidares*, the form of the spine varies according to its position on the test; those at the peristome are tolerably cylindrical, with an acute apex; those at the ambitus are inversely conical, with the apex less acute, and those at the anal margin have the body inflated and the apex somewhat obtuse. The peristome spines have the surface covered with coarser granulations than is the case with those which occur on the opposite side. At Southeram Pit, near Lewes, Sussex (Lower Chalk), tests with the spines *in situ* are occasionally found. In my cabinet is a specimen from Southeram Pit nearly perfect, in which almost the whole series of spines, from the anal to the oral region, are in position, and in which the variation of form in these spines, according to their situation, is well exhibited. From this specimen were drawn the figures shown in the woodcuts fig. 4 *a—d*, which are twice the size of the originals; *a* is the spine

in connection with the tubercle adjacent to the anal margin; *b* that on the next tubercle, counting downwards; *c* that beneath *b*; and *d* that below *c*, on the tubercle which is the third from the peristome: *a* is in length five tenths of an inch, in diameter three tenths; *d* is in length two tenths of an inch, in diameter one twentieth. The test from which these spines are derived is five twentieths of an inch in height, and nine twentieths in transverse diameter.

Fig. 4.

Spines of *Cidaris Bowerbankii*; magnified two diameters.

"Several of the spines of this species from different localities are figured on Pl. XIII; figs. 9, 10, and 11 are from Folkestone, figs. 13 and 14 from Cambridge, 8 from near Arundel, from which last-mentioned locality also come the plates of *C. dissimilis*, figured Pl. XIII, figs. 6 *a*, 6 *b*. In all these a certain variation in general form is very perceptible.

"*Cidaris Bowerbankii* has great affinities in its test with *C. clavigera*, but is always much smaller in size. It is a very rare species. The horizon of *C. Bowerbankii* at Folkestone is just above the Upper Greensand.

"At Folkestone, in company with the spines of *C. Bowerbankii*, occur globose spines with a short neck, and having the body covered with coarse spiny projections arranged longitudinally. They are drawn of the natural size in the woodcut fig. 5; they appear to differ from *C. relifera*, and are perfectly distinct from the spines of *C. Bowerbankii*.

Fig. 5.

Spines of a *Cidaris* from the Lower Chalk at Folkestone; natural size.

"Additional Note on the *CIDARES* from the Red Chalk. (See p. 44.)

"In the thin red-coloured band met with at Hunstanton, in Norfolk, and in the lowest of the pink-coloured beds at Speeton, in Yorkshire, occasionally occur elongate, cylindrical

spines, which do not exactly agree with those previously referred to in this Monograph; four of these are drawn on Pl. XII, of which figs. 7, 8, and 9 are from Hunstanton, and fig. 10 from Speeton. They may be divided into three classes—(α) slender, having few (ten to sixteen) longitudinal ridges, with a prickly border, Pl. XII, figs. 7 and 9; (β) thick, having numerous longitudinal ridges, with the prickles almost obliterated, Pl. XII, fig. 10; and (γ) slender, without ridges, but with an occasional projecting prickle.

"The drawing, Pl. XII, fig. 7, represents a magnified view (the natural size being depicted by a black line) of the expanded extremity of a spine with twelve ridges, not unlike in its general character that to be met with in some forms of the spines of *Cidaris Gaultina*, but differing from the latter in the valleys between the ridges being covered with very fine longitudinal lines, instead of being marked with fine granulations. Fig. 9, with ten ridges, is marked also by the fine longitudinal striæ, and the absence of granulations in the valleys; the lines of spiny projections or prickles are thinner, more conspicuous, sharper, and less numerous than in the spines of *C. Gaultina;* it is very slightly tapering; the fragment preserved measures an inch in length, and must when perfect have been at least two inches; in general aspect it bears a strong resemblance to *C. subvesiculosa* from the Upper Chalk.

"The spine fig. 10 *a* (natural size), and fig. 10 *b* (a portion magnified) is found both at Speeton and Hunstanton; the specimen figured, which was from Speeton, and is not quite perfect, measures one inch and a half in length, and is two tenths at its greatest diameter; the body of the spine increases very gently in diameter for a short distance from the acetabulum, and then as gently diminishes; the margin of the acetabulum is crenulated, a double milled ring surrounds the head, the neck is short and smooth, and the body is marked by about thirty longitudinal ridges, which are crowned by small and obtuse spiny projections. The valleys between the ridges are covered with fine longitudinal striæ; the general aspect is that of a spine of *C. dissimilis*, but the latter generally has the spines much more slender.

"Fig. 8, from Hunstanton, is only a fragment, half an inch in length, and one tenth of an inch in diameter; it is uniformly cylindrical, with the surface quite smtooh and without striæ; arising from the smooth surface are stout prickles, like thorns, which are repeated in longitudinal lines at about the distance of the tenth of an inch apart from each other. It is a very peculiar spine, totally distinct from all those of the Cretaceous species, and mostly resembles the spine of *C. perornata* from the Upper Chalk; in the latter, however, the prickles arise from a small longitudinal ridge, and are not isolated and unconnected. The same form of spine occurs at Speeton. In the ratio of frequency, the form α is more common than that of β; and the forms α and β are more common than that of γ, which is very rare."

Family 2.—Hemicidaridæ. (Not yet found in British Cretaceous strata.)

Family 3.—Diademadæ.

This Family includes large and small Urchins having a thin, circular, pentagonal, and subpentagonal test, more or less depressed on the upper surface, and flat at the base.

The ambulacral areas are wide and straight, with two rows of primary tubercles, often as large and numerous as those of the inter-ambulacral areas.

The poriferous zones are narrow, almost always straight, and sometimes subflexuous; the pores are unigeminal, bigeminal, and trigeminal in their arrangement in different genera.

The inter-ambulacral areas are in general twice the width of the ambulacral, and occupied, at the equator, with two, four, six, or eight rows of primary tubercles, which diminish gradually in number near the poles. The bosses of all the tubercles are small; their summits, in general, are crenulated, sometimes uncrenulated; the tubercles are small, in general perforated, in *Cyphosoma* imperforate; they are in general a little larger than those of the ambulacra; but are often of equal magnitude in both areas.

The apical disc is small, and situated opposite to the mouth; it is composed of five ovarial and five ocular plates; the anterior pair of ovarial plates are a little larger than the posterior pair, and the right antero-lateral plate, with a small, spongy, madreporiform body on its upper surface, is the largest; the vent is round or oblong, and generally in the centre of the disc; the ocular plates are very small, and distinguished with difficulty.

The mouth-opening is in general large and decagonal, and the peristome divided into ten lobes by deep notches; the jaws in general are large and powerful.

The spines in existing genera are long, slender, and tubular, sometimes three times as long as the diameter of the test.[1] In the fossil extinct genera they rarely attain the length of the diameter of the test, and are short, stout, and solid, except in *Hemipedina*, which have long hair-like spines. The long tubular spines of living Diademas, and a rare form from the Cretaceous rocks, are encircled by spiral verticellate processes, or fringe-like scales, Pl. XIV, fig. 2, whilst the surface of the solid spines of Pseudodiademas is in general covered with fine longitudinal lines; neither prickles or asperities being developed on their stems.

Lamarck divided the genus *Cidaris* of Klein into two sections, "*Les Turbans*" and "*Les Diadèmes*;" these were afterwards by Dr. Gray[2] erected into genera; the *Cidaris radiata*, Leske, constituting a third type, formed his new genus *Astropyga*. The genus *Cidarites* of Lamarck was considered to form a natural family, including the genera *Cidaris*, *Diadema*, and *Astropyga*, which he constituted and characterised thus:—

[1] Peters, 'Ueber Gruppe der Diademen,' p. 2, 101. Königl. Akademie der Wissenchaften Augt., 1853, Berlin.

[2] 'Annals of Philosophy,' new series, vol. x, p. 426, 1825. "An attempt to divide the Echinidæ or Sea-Eggs into natural families."

1. *Family*—CIDARIDÆ. *Cidarites*, Lamarck.

Body with spines of two sizes; larger ones either club-shaped or very long; spine-bearing tubercles perforated at the summit.

Genus 1—CIDARIS, *Klein*, *Lamarck*. (LES TURBANS.)

Body depressed, spheroidal; ambulacra waved; small spines compressed, two-edged, two-rowed, covering the ambulacra, and surrounding the base of the larger spines.

This genus may be divided according to the form of the larger spines: the extra-ambulacral beads have only two rows of spines.

CIDARIS IMPERIALIS, *Lamk.* Klein., Nat. dispositio Echinodermatum, tab. vii, fig. A.

Genus 2—DIADEMA, *Gray*. (LES DIADÈMES.)

Body orbicular, rather depressed; ambulacra straight; spines often fistulous.

ECHINOMETRA SETOSA, *Rumph.* Leske, Klein., Nat. disp. Echinid., tab. xxxvii, fig. 1, 2.
ECHINUS DIADEMA, *Linn.* Syst. Nat., by Turton, vol. iv, p. 139.
— CALAMARIA, *Pallas.* Spicil. Zool., tab. ii, fig. 4—8.

Genus 3—ASTROPYGA, *Gray*.

Body orbicular, very much depressed; ambulacra straight; ovarial scales very long, lanceolate; beads with several series of spines.

CIDARIS RADIATA, *Leske*, apud *Klein*, tab. xliv, fig. 1.

The very meager characteristics by which Dr. Gray has defined the last two genera merely shows that a difference exists, and his description is insufficient for a correct diagnosis of either; hence the various opinions extant regarding the character and limits of his genus *Diadema;* only one of the species enumerated as types, *Diadema setosa*, Rumph.,

is admitted to be a true *Diadema*. The valuable memoir of Herr W. Peters[1] has removed some of the difficulties that surrounded this subject, and his grouping of the living Diademas makes an important step towards a natural classification of one section of this Family. Although the present state of our scientific knowledge of the *Diademadæ* may be considered as transitional rather than positive, still we possess enough to justify the separation of fossil Diademas from existing genera, as proposed by M. Desor.[2]

The Diademadæ, in fact, appear to consist of two types; one of these, with a few rare exceptions, appertains to the present epoch, the other existed during the deposition of the Secondary and Tertiary rocks. The living forms are in general large, depressed Urchins, with thin shells, having the tubercles and pores variously arranged in the different genera. They have, in general, very long, slender, *tubular* spines, and the surface of the stem is covered with oblique annulations of small imbricated scales. The fossil species, on the contrary, are smaller Urchins, with a thicker test; having the tubercles and pores variously disposed in different genera; the spines rarely attain the length of the diameter of the test; they are in general *solid*, cylindrical, sometimes flattened or awl-shaped, and their surface is covered with fine longitudinal lines. I propose to include the following genera in this natural family.

A Table showing the Classification of the Diademadæ.

DIADEMADÆ

Section A.

Spines very long, slender, tubular, covered with oblique annulations of imbricated scales. Living in tropical seas.	Diadema, *Gray.*
	Savignya, *Desor.*
	Astropyga, *Gray.*
A few annulated tubular spines are found in the Upper Chalk and in the Coralline Crag.	Echinothrix, *Peters.*

Section B.

Spines short, slender, solid; surface covered with fine longitudinal lines.	Pseudodiadema, *Desor.*
	Cyphosoma, *Agassiz.*
	Hemipedina, *Wright.*
Extinct; found in the Oolitic, Cretaceous, and Tertiary Rocks.	Pedina, *Agassiz.*
	Echinopsis, *Agassiz.*

My learned friend M. Cotteau,[3] in his classical work on the Echinidæ of France, has lately proposed an extended classification of the family Diademadæ, a *résumé* of which I

[1] 'Ueber die Gruppe der Diademen, Konigl. Akademie der Wissenschaften,' Berlin Aug., 1853.

[2] 'Synopsis des Échinides Fossiles.'

[3] 'Paléontologie Française, Terrain Crétacé,' tom. vii, p. 371.

herewith subjoin; the genera referred to this family are divided into four groups, based upon the structure of the tubercles, whether they are perforated or not perforated, and crenulated or not crenulated.

In the CIDARIDÆ these characters have not much significance, and are present or absent in many species of congeneric forms; in the DIADEMADÆ, however, they are more stable and persistent, and have served to form a great number of genera. If from an organic point of view this structure of the tubercles is only of secondary importance, in a palæontological sense it affords a character which is readily seen, and nearly always well preserved.

The first group comprehends the DIADEMADÆ[1] with tubercles perforated and crenulated: *Hemicidaris*, Agassiz; *Acrocidaris*, Agassiz; *Pseudodiadema*, Desor; *Diadema*, Gray; *Hibertia*, Michelin; *Microdiadema*, Cotteau; *Heterodiadema*, Cotteau; *Asterocidaris*, Cotteau; *Glyphocyphus*, Haime.

The second group includes the genera with tubercles perforated and not crenulated: *Cidaropsis*, Cotteau; *Diademopsis*, Desor; *Hemipedina*, Wright; *Echinopsis*, Agassiz; *Orthopsis*, Cotteau: *Pedinopsis*, Cotteau.

The third group is destined to receive the genera which have the tubercles imperforated and crenulated: *Cyphosoma*, Agassiz; *Micropsis*, Cotteau; *Temnopleurus*, Agassiz; *Echinocyphus*, Cotteau.

The fourth and last group contains the genera with tubercles imperforated and uncrenulated: *Goniopygus*, Agassiz; *Acropeltis*, Agassiz; *Leiosoma*, Cotteau; *Echinocidaris*, Desmoulins; *Cœlopleurus*, Agassiz; *Kœraiaphorus*, Michelin; *Codiopsis*, Agassiz; *Cottaldia*, Desor; *Magnosia*, Michelin; *Glypticus*, Agassiz; *Temnechinus*, Forbes; *Opechinus*, Desor.

The genera which compose these four groups are distinguished by straight or flexuous ambulacra, the disposition of the tubercles, the structure of the apical disc, the sutural and angular impressions which mark the ambulacral and inter-ambulacral plates, the comparative width of the peristome, and the form and structure of the spines.

The following table contains a definition of the opposable characters of the thirty-one genera composing the family DIADEMADÆ.

[1] In my classification of the ECHINIDÆ I have separated *Hemicidaris* and *Acrocidaris* as a distinct family, the HEMICIDARIDÆ.

A. Tubercles crenulated and perforated.

a. Ambulacral areas subflexuous, provided with large tubercles at the ambitus and inferior surface . . . . . HEMICIDARIS.

b. Ambulacra straight, provided with tubercles in all their extent.

x. Ambulacral and inter-ambulacral plates without angular impressions.

x. Inter-ambulacral areas subgranular as they approach the summit.

y. Apical disc subpentagonal, peristome large.

z. Each of the ovarial plates of the apical disc carry a large tubercle . ACROCIDARIS.

zz. Apical disc, without a large tubercle on its ovarial plates.

1. Poriferous plates unequal and irregular.

φ. Spines solid, aciculated, striated . . . . PSEUDODIADEMA.

φφ. Spines tubular, verticillated . . . . DIADEMA.

2. Poriferous plates straight, equal, regular . . . . HIBERTIA.

yy. Apical disc narrow, annular, peristome reentrant . . MICRODIADEMA.

yyy. Apical disc elongated, prolonged into the middle of the single inter-ambulacral area; peristome narrow . . . HETERODIADEMA.

xx. Inter-ambulacra smooth near the summit, and presenting a stellate appearance . . . . . ASTERIOCIDARIS.

xx. Ambulacral and inter-ambulacral plates marked with angular impressions . GLYPHOCYPHUS.

B. Tubercles perforated and not crenulated.

a. Ambulacra subflexuous, provided with tubercles only towards the ambitus and inferior surface . . . . CIDAROPSIS.

b. Ambulacra straight, provided with tubercles in all their extent.

x. Pores simple near to the summit.

x. Ambulacral plates unequal, irregular.

y. Apical disc largely developed, peristome wide.

z. Miliary zone extended; principal inter-ambulacral tubercles very large, placed on the external border of the plates . . . DIADEMOPSIS.

zz. Miliary zone narrower, tubercles tolerably large and placed in the middle of the plates . . . . . HEMIPEDINA.

yy. Apical disc narrow, peristome slightly developed, tubercles very small. ECHINOPSIS.

xx. Ambulacral plates, straight, regular, sutures very apparent . . ORTHOPSIS.

xx. Pores in double series at the superior surface and towards the ambitus . PEDINOPSIS.

C. Tubercles not perforated and crenulated.

a. Ambulacral and inter-ambulacral plates without angular impressions.

x. Form depressed, tubercles rather large, peristome widely open . . CYPHOSOMA.

xx. Form inflated, tubercles small, peristome narrow . . . MICROPSIS.

b. Ambulacral and inter-ambulacral plates marked with angular, and sutural impressions.

x. Apical disc sub-circular, inter-ambulacral tubercles forming many rows towards the ambitus . . . . . TEMNOPLEURUS.

xx. Apical disc pentagonal, inter-ambulacral tubercles forming two rows . ECHINOCYPHUS.

D. Tubercles not perforated and not crenulated.

a. Ambulacral and inter-ambulacral plates without angular and sutural impressions.

x. Apical disc smooth, ovarial and ocular plates perforated below at their external angle . . . . . GONIOPYGUS.

xx. Apical disc furnished with a large tubercle on each ovarial plate; ovarial and ocular plates perforated at some distance from the border . ACROPELTIS.

xxx. Apical disc granular, deprived of tubercles; ovarial and ocular plates perforated at some distance from the border.

x. Tubercles rather large, forming regular vertical rows.

y. Two rows only of inter-ambulacral tubercles; mammelon large and prominent . . . . . LEIOSOMA.

yy. More than two rows of inter-ambulacral tubercles; mammelon small . ECHINOCIDARIS.

yyy. Inter-ambulacral tubercles not extending above the ambitus; inter-ambulacral area forming, at the upper part, a depressed zone, perfectly circumscribed.

z. Four rows of inter-ambulacral tubercles towards the ambitus . CŒLOPLEURUS.

zz. Two rows of inter-ambulacral tubercles towards the ambitus; spines long, sub-tricarinated, and slightly bent . . . KÆRAIAPHORUS.

yyyy. Ambulacral and inter-ambulacral tubercles limited to the inferior surface, replaced above the ambitus by caducous granules . . CODIOPSIS.

xx. Tubercles small, forming very regular horizontal rows.

y. Peristome small, pores simple towards the ambitus . . COTTALDIA.

yy. Peristome very wide, sub-pentagonal, pores forming double rows from the ambitus to the mouth . . . . MAGNOSIA.

D. Tubercles not perforated and not crenulated—*continued.*

yyy. Inter-ambulacral tubercles irregularly arranged above the ambitus, often lacerated . . . . . GLYPTICUS.

b. Ambulacral and inter-ambulacral plates provided with angular and sutural impressions.

x. Impressions angular . . . . . TEMNECHINUS.

xx. Impressions sutural, and angular, and much more defined . . OPECHINUS.

The stratigraphical distribution of the Diadematidæ extends from the Trias to the modern epoch, where a few species now live in tropical seas. Of the thirty-one genera enumerated in the above table, seven are proper to the Oolitic period: *Microdiadema*, *Asterocidaris*, *Cidaropsis*, *Hemipedina*, *Acropeltis*, *Glypticus*. Seven to the Cretaceous period: *Heterodiadema*, *Glyphocyphus*, *Orthopsis*, *Pedinopsis*, *Echinocyphus*, *Leiosoma*, *Codiopsis*. Five are special to the Tertiary period: *Hibertia*, *Echinopsis*, *Cœlopleurus*, *Temnechinus*, *Opechinus*. Three to the Modern period: *Diadema*, *Echinocidaris*, and *Kœraiaphorus*. One genus, *Pseudodiadema*, is common to the Oolitic, Cretaceous, and Tertiary periods. Three genera are found in the Oolitic and Cretaceous periods; *Hemicidaris*, which commenced in the Trias, *Acrocidaris* and *Magnosia*, but neither extend above the Neocomian. Four genera are common to the Cretaceous and Tertiary periods: *Goniopygus*, *Coltaldia*, *Cyphosoma*, and *Micropsis*. The genus *Temnopleurus* appeared in the Tertiary period and exists in our present seas.

PSEUDODIADEMA, *Desor.* 1854.

This genus is composed of small Urchins with a moderately thick test, which rarely attains two inches in diameter; the ambulacral areas in general are one third or even one half the width of the inter-ambulacral areas; the primary tubercles of both areas are perforated, and nearly all of the same size; the bosses are small, and have sharply crenulated summits.

The ambulacral areas have two rows of tubercles; the inter-ambulacral areas two rows only, or two rows of primary and two or four short rows of smaller secondary tubercles, or they have four, or six rows of nearly equal-sized primary tubercles at the ambitus.

The poriferous zones in general are narrow and straight; the pores in one section are unigeminal throughout, and in another they are bigeminal in the upper part of the zones. The apical disc is small; and the anterior ovarial plates are larger than the posterior pair.

The mouth-opening is large, the peristome deeply notched, and the oral lobes are nearly equal.

The spines rarely attain the length of the diameter of the test; in general they are much shorter, cylindrical, or needle-shaped, and have a prominent, milled ring near the articulating head; the rim of the acetabulum is crenulated, and the socket perforated; the surface of the stem is sculptured with delicate longitudinal lines.

The *Pseudodiademata* are all extinct, and found in the Liassic, Oolitic, Cretaceous and Tertiary rocks.

Pseudodiadema differs from *Diadema* in having solid spines, with a smooth surface, the sculpture, in most cases, consisting of microscopic, longitudinal lines; whilst in *Diadema* the spines are tubular, and have oblique annulations of scaly fringes on their surface. *Pseudodiadema* differs from *Cyphosoma*, a Cretaceous genus, in having the tubercles always perforated, those of *Cyphosoma* being imperforate. It differs from *Hemipedina* in having a small apical disc, and tubercles with crenulated bosses, those of *Hemipedina* being smooth; and from *Pedina* in having the pores unigeminal or bigeminal, those of *Pedina* being arranged in triple, oblique pairs.

Pseudodiadema may be divided into two sections, from the different manner the pores are arranged in the zones. In one group the pairs of pores form a single file throughout; in another the pores are more numerous, and crowded together in the upper part of the zones. Professor M'Coy has proposed the genus *Diplopodia* for the latter. It may be objected, however, that the crowding together of a greater number of pores in a zone is, at most, a sectional and not a generic character, inasmuch as the arrangement is subject to great variation in the diplopodous species themselves, and is, moreover, often only an adult development.

A.—*Species from the Lower Greensand.*

PSEUDODIADEMA ROTULARE, *Agassiz.* Pl. XIV, figs. 3 *a*, *b*, *c*.

DIADEMA ROTULARE,	*Agassiz.*	Mém. des Sc. nat. de Neuchâtel, vol. 1, p. 139, tab. xiv, figs. 10—12, 1836.
— —	*Des Moulins*,	Études sur les Échinides, p. 316, No. 25, 1837.
— ORNATUM,	*Agassiz.*	Catal. Syst. Ectyp. foss. Musei Neoc., p. 8, 1840.
— ROTULARE,	*Agassiz.*	Descript. des Échin. foss. de la Suisse, part 2, p. 4, tab. xvi, fig. 1—5, 1840.
— MACROSTOMA,	*Agassiz.*	Ibid., p. 10, tab. xvi, fig. 22—26, 1840.
— ROTULARE,	*Agassiz* et *Desor.*	Catal. Raison. des Échinides, Ann. des Sc. nat, 3e série, t. vi, p. 346, 1846.
— MACROSTOMA,	*Agassiz* et *Desor.*	Ibid., p. 347, 1846.
— —	*Bronn.*	Index Palæontologicus, p. 418, 1846.
— CORONA,	*Gras.*	Oursins foss. de l'Isère, p. 33, pl. i, fig. 21—23, 1848.
— ROTULARE,	*Marcou.*	Recherch. géol. sur le Jura Salinois, Mém. Soc. Géol. de France, 1re série, t. iii, p. 143, 1848.

Diadema rotulare,	*D'Orbigny.* Prod. de Paléont. Strat., t. ii, p. 89 ; Ét. 17, No. 489, 1850.
— macrostoma,	*D'Orbigny.* Ibid., No. 491, 1850.
— rotulare,	*Cotteau.* Cat. Éch. Néocom., Bull. Soc. de l'Yonne, t. v, p. 285, 1851.
Diadema dubium,	*Sharpe.* Sands and Gravels of Farringdon, Quart. Journ. Geol. Soc., vol. x, p. 194, 1853.
— —	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 76, 1854.
— rotulare,	*Cotteau.* Paléontologie Française, Ter. Cretacè, vol. vii, p. 422, pl. 1097, figs. 11—13 ; pl. 1098 and 1099.
Pseudodiadema —	*Desor.* Synopsis des Échinides fossiles, p. 69, 1856.
— macrostoma,	*Desor.* Ibid., p. 68.
— rotulare,	*Cotteau.* Études sur les Échinides de l'Yonne, t. ii, p. 24, pl. xlix, figs. 1—5, 1857.
— pieteti,	*Cotteau.* Ibid., p. 31, pl. l, figs. 7—10, 1857.
— triseriale,	*Desor.* Synop. des Échin. foss., p. 445 (Suppl.). 1858.
— rotulare,	*Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Échinoderm., p. 428, 1862.
— periqueti,	*Dujardin* et *Hupé.* Ibid.
— macrostoma,	*Dujardin* et *Hupé.* Ibid.
— triseriale,	*Dujardin* et *Hupé.* Ibid.

Test small, circular, slightly pentagonal, moderately convex above, and flat below; poriferous zones narrow, straight; pores in single file; ambulacral areas large, two rows of close-set marginal tubercles; inter-ambulacral areas, four rows of tubercles at the ambitus, the outer rows disappearing on the upper surface; miliary zone wide, depressed near the disc, and covered with an abundance of well-formed granules. Mouth-opening large, decagonal; peristome deeply notched; lobes unequal.

Dimensions.—Height four tenths of an inch; transverse diameter, one inch.

Description.—This is a very rare Urchin from the remarkable deposit of fossiliferous sands and gravels near Farringdon in Berkshire, about the age of which so many different opinions have been given; perhaps the Echinidæ found therein may assist to determine the problem whether these beds belong to the Lower Greensand, or to a "more modern member of the Cretaceous Series than the Chalk," as maintained by the late Mr. Daniel Sharpe, F.G.S.[1] The Diadema now before us is a well-known and characteristic species, of the middle stage of the Neocomian formation, containing *Echinospatagus cordiformis;* and the extensive table of synonyms prefixed to this article shows how widely it is distributed in beds of the same age on the continent of Europe.

The test is of medium size, circular or slightly pentagonal, moderately convex on the upper surface, and nearly flat beneath.

[1] "On the Age of the Fossiliferous Sands and Gravels of Farringdon and its Neighbourhood," 'Quart. Journ. of the Geological Society,' vol. x, p. 176. 1853.

The ambulacral areas are wide (fig. 3 *a*, *b*) and have two rows of tubercles placed on the margin of the area; these are small, uniform in structure, set closely together, and gradually diminish from the equator to both poles; a band of granulations down the middle of the area divides the two series from each other: the poriferous zones are narrow and straight (fig. 3 *b*); the pores are round and simple, and arranged in a single file throughout the zones (fig. 3 *c*).

The inter-ambulacral areas are occupied at the ambitus by four rows of tubercles; the inner rows extend from the mouth to the disc, and the outer rows diminish in size on the upper surface and disappear before reaching the disc; the tubercles forming the inner row are about the size of those in the ambulacra; those of the outer row are sensibly smaller (fig. 3 *b*). The miliary zone is large, and slightly depressed near the summit; it is filled with numerous granules of unequal sizes, some of which are mammillated and perforated; the granules are disposed in circles around the areolæ, and fill the entire area of the zones with a beautiful ornamentation; the examples from Farringdon have lost much of this character from the process of fossilization in those gravel beds.

The base of the test is flat, and presents a highly tubercular surface (fig. 3 *a*), the four rows of tubercles in the inter-ambulacral areas being all distinctly developed in this region. The mouth-opening, one half the diameter of the test, is proportionally large: the peristome is deeply notched into the lobes, the ambulacral portions being one half larger than those of the inter-ambulacral arches. In fig. 3 *c*, I have given a section of the base, magnified four diameters, showing the relation of all these parts to each other.

Affinities and Differences.—This Urchin presents many varieties of form, which have been described by different authors as so many distinct species, an error that has been now corrected, as shown in the table of synonyms. It resembles *P. Bourgueti*, Ag., found with it in the same Neocomian beds, but is distinguished from that species in having the primary tubercles less developed, more closely set together, and more homogeneous; and in the secondary or outer series of tubercles being larger and more regularly arranged; they are, however, nearly allied forms of one type of structure.

Locality and Stratigraphical Position.—This Urchin in England has hitherto been found only in the sands and gravels near Farringdon, where it is extremely rare. It was collected from these beds by the late Mr. D. Sharpe, and I obtained one specimen in the same locality. On the continent of Europe it is one of the most characteristic fossils of the "Terrain Néocomien," and is found principally in the middle beds of that formation. M. Cotteau records the following localities in France where it has been collected:—Billécul, Miéges, et l'ermitage de Censeau, Nozeroy (Jura): Morteau, Hautepierre (Doubs); Germigney (Haute-Saône); Vassy, Bettancourt, (Haute-Marne): Thieffrain, Vandœuvre, Marolles (Aube); Cheney, Flogny, Moneteau, Auxerre, Gy-l'Évêque, Leugny, Fontenoy, Saints, Pereuse (Yonne); in all these localities it is collected in abundance from the Middle Neocomian: and at Le Rimet (Isère), Villefargeau, Perrigny (Yonne), it is very rare in the Upper Neocomian. In Switzerland it is found near Locle in the Lower

Neocomian; and at Landeron, Sainte-Croix, Hauterive in the Middle Neocomian, so that it forms a leading fossil of the Neocomian formations.

History.—This Urchin was at first referred by Professor Forbes to the *Diadema dubium* of Albin Gras, but a careful comparison of specimens proved this to be an error. It appeared under that name in Mr. Sharpe's list of Echinodermata from the sands and gravels of Farringdon, and in the second edition of the 'Catalogue of British Fossils.'

PSEUDODIADEMA FITTONI, *Wright.* Pl. XV, Figs. 1, *a*—*g*.

DIADEMA AUTISSIODORENSE, *Wright.* Ann. and Mag. of Nat. History, New Series, vol. x, p. 91, 1852.

Test pentagonal, depressed; inter-ambulacral areas with two rows of primary tubercles and two incomplete series of small secondary tubercles, which disappear on the upper surface; ambulacral areas prominent, with two rows of primary tubercles much diminished in size at the upper surface; poriferous zones narrow, subflexuous. Pores bigeminal near the ovarial disc, and at the circumference of the mouth.

Dimensions.—Height four tenths of an inch; transverse diameter nineteen twentieths of an inch.

Description.—In its general outline this beautiful Urchin resembles *P. depressum* of the Inferior Oolite; in the details of structure, however, it is very distinct from that form. The circumference is pentagonal, from the convexity of the ambulacral areas, and the upper and under surfaces are much depressed (Pl. XV, fig. 1 *a*, *b*, *c*, *d*).

The inter-ambulacral areas are one third broader than the ambulacral; two rows of primary tubercles occupy the centre of the plates; there are about ten pairs of tubercles in each area, which are of a moderate magnitude, and gradually diminish in size from the ambitus to the base and summit; the mammillary eminences are small, their summits sharply crenulated, and the tubercles, of proportional size, are deeply perforated (fig. 1 *g*); at the ambitus six rows of granules separate the tubercles from each other (fig. 1 *e*); towards the upper part of the miliary zone the four central rows are absent, leaving a naked space in the middle of the area; three rows of granules in like manner separate the tubercles from the poriferous zones; at the base of the area, and extending as far as the ambitus, there are incomplete rows of small secondary tubercles; these gradually diminish in size, and disappear at the upper surface, which is occupied with an unequal close-set granulation about three rows deep (fig. 1 *b*); the ambulacral areas, one third narrower than the inter-ambulacral, are very prominent and convex, and occupied by two rows of primary tubercles about ten in a row; the lower six pairs of tubercles are nearly as large as the corresponding tubercles in the inter-ambulacral areas, but the upper

four pairs are much smaller, so that, whilst there is a great uniformity in the size and form of the tubercles at the base and ambitus of the test, there is a very marked difference between those of the ambulacra and inter-ambulacra in the vicinity of the apical disc (fig. 1 *b*) ; the inter-tubercular space is occupied by a zigzag band of granulation, which is narrow below where the tubercles are large, and broader above where they are small (fig. 1 *c*). The poriferous zones are narrow and subflexuous; and the pores arranged in single pairs ; near the disc they are slightly bigeminal ; the apical disc is absent in our specimen. The mouth-opening is large and the peristome slightly decagonal (fig. 1 *c*).

Affinities and Differences.—*Pseudodiadema Fittoni* nearly resembles *P. Bourgueti*, Ag., but differs from it in the rudimentary condition of the upper tubercles of the ambulacra, and in having the intermediate granulation on the miliary zone less homogeneous.

Locality and Stratigraphical Position.—I collected this Urchin from the Lower Greensand at Atherfield, in bed No. 4 of the Cracker group, Dr. Fitton's section ; it must be very rare, as none of the cabinets of Atherfield fossils hitherto examined by me contain a specimen.

History.—I discovered this fossil in 1850, and in the first instance erroneously identified it with a specimen found in France, and then briefly described by M. Cotteau as *Diadema Autissiodorense*. The fine figures and detailed description lately published by M. Cotteau in his additions to the "Paléontologie Française" have enabled me to correct my error, and I now dedicate this species to the memory of my late friend Dr. Fitton, F.R.S., whose admirable memoir on the Atherfield section and the strata below the Chalk will long remain models of patient research and accurate scientific investigation.

PSEUDODIADEMA MALBOSI, *Agassiz & Desor.* Pl. XX, figs. 1, *a—f.*

DIADEMA MALBOSI,	*Agassiz* and *Desor.* Catal. rais. des Échinides, Ann. Science. Nat., 3me sér., t. vi, p. 350, 1846.
— —	*D'Orbigny.* Prodrome de Paléont. strat., t. ii, p. 201, 1850.
DIPLOPODIA —	*Desor.* Synops. des Échinides fossiles, p. 78, pl. xii, figs. 12—14, 1856.
— —	*Leymerie* et *Cotteau.* Catal. des Échinid. Foss. des Pyrenées, Bullet. Soc. Géol. de France, 2e sér., t. xiii, p. 324, 1856.
DIADEMA MACKESONI,	*Forbes.* Woodward's Notes on British fossil Diadems, Mem. Geol. Surv., Decade V, 1856.
— MACKIEI,	*Woodward.* Ibid.
— MALBOSI,	*Pictet.* Traité de Paléont., 2e éd., t. iv, p. 245, 1857.
DIPLOPODIA —	*D'Archiac* les Corbières. Mém. Soc. Géol. de France, 2e sér., t. vi, p. 384, 1859.

Diplopodia Malbosi, *Dujardin* et *Hupé*. Hist. Nat. des Zooph. Échinodermes, p. 501, 1862.
Pseudodiadema Malbosi, *Cotteau*. Échinid. Foss. des Pyrenées, p. 26, 1863.
— — *Cotteau*. Paléontologie Française, Ter. Crétacé, tom. vii, p. 448, pls. 1106 et 1107, 1865.

Test large, subcircular, upper surface convex, slightly inflated, base rounded and flattened, ambulacral areas narrow, contracted at the upper part by the width of the poriferous zones, two rows of tubercles twenty to twenty-two in each row. Inter-ambulacral areas wide with four, six, or eight rows of tubercles at the equator, the two inner rows having eighteen to twenty tubercles in each, extend from the peristome to the disc, all the others disappear at different points on the sides. Small secondary tubercles scattered irregularly among the primary series in the inferior part of the areas. Poriferous zones narrow at the base and sides; pores in double file from the ambitus to the disc, where they increase in width, and on the upper third are largely bigeminal. Mouth-opening moderate in size; peristome nearly equal lobed; discal opening large and acutely pentagonal.

Dimensions.—Transverse diameter two inches; height thirteen twentieths of an inch.

Description.—This is a very rare British Urchin, and as nearly all the tests have been either broken, crushed, or otherwise distorted, it is difficult to form a correct idea of its form. I have carefully examined the original specimens collected by Mr. Mackeson, F.G.S., from the Lower Greensand at Hythe, and presented by him to the Royal School of Mines; these I have compared with a series collected by my friend the Rev. T. Wiltshire, from the Lower Greensand at Whales' Chine, Isle of Wight, with which they agree, and both correspond with the figures and description of *Pseudodiadema Malbosi* given by M. Cotteau in the 'Paléontologie Française,' and with a good type specimen kindly presented to me by M. Bayle, of the École des Mines, Paris. I have no hesitation, therefore, in considering *D. Mackesoni*, Forb., identical with *D. Malbosi*, Agass. It is important likewise to note that both belong to the same geological horizon; the French specimens were collected from the Upper Neocomian, associated with *Echinospatagus Collegnii*, Sism., and the British specimens from the Lower Greensand at Hythe, and the Crioceras-beds, Lower Greensand, at Whales Chine, Isle of Wight, the English equivalent of the Continental Neocomian formation.

This Urchin attains a considerable size; Mr. Wiltshire's cabinet contains a specimen measuring two and a half inches diameter. The base of this fossil is nearly circular, and only slightly pentagonal. In some of the Hythe specimens in the Museum of the Royal School of Mines, the upper surface is convex and moderately inflated, and the base rounded and flattened.

The ambulacral areas are narrow and contracted at their apices by the width of the poriferous zones above (fig. 1, *g*); they are slightly inflated, and furnished with two

rows of large tubercles, from twenty to twenty-five in each, according to the size of the Urchin, all deeply crenulated and perforated, and gradually diminishing from the equator to the apertures; a single sinuous line of granules separates the tubercles, which are placed closely together in the area (fig. 1 *d*).

The poriferous zones are narrow at the base and sides, where the pores are arranged in a single file (fig. 1 *e*); at the upper part they are bigeminal (fig. 1 *d*), the double rows encroaching on the width of the ambulacral area and diminishing the size of the tubercles therein.

The poriferous plates are prolonged to the base of the tubercles in more or less apparent irregular sutures (fig. 1 *d*).

The inter-ambulacral areas are widely developed, the large plates support tubercles closely resembling those of the ambulacra (fig. 1 *g*). In the figured specimen there are six rows at the equator, and in larger specimens there are eight distinct rows. The two internal rows have eighteen tubercles a little larger than the others, extending from the peristome to the disc; the other rows have a more limited range, and disappear on the upper surface. It is only in the largest specimens that eight rows are found at the ambitus, the tubercles of the shorter rows being a little less than those of the two internal series (fig. 1 *g*); besides the primary tubercles a number of small secondary tubercles are crowded along each side of the median suture, between the peristome and the ambitus, and others occupy spaces by the side of the poriferous zones. The miliary zone is wide, smooth, and depressed at the upper surface; the granules are irregularly scattered on its lower half, and some of them are even developed into small mammillated tubercles on the upper surface; they form hexagonal circlets around the areas of the primary tubercles; the median suture is very well defined, and lies in a smooth depression of the test (fig. 1 *a*, *c*).

The mouth-opening (fig. 1 *b*) is large and pentagonal, and the peristome divided into lobes of unequal sizes; the arches that span the ambulacra are longer than those of the inter-ambulacra.

The apical disc was very large; the opening is pentagonal and acutely angular, the angles extending far into the median suture of the inter-ambulacra (fig. 1 *a* and *g*).

The spines are slender, and circular; above the milled ring of the head, there is a short portion of the stem ornamented with fine longitudinal lines (fig. *f*), whilst the portion beyond is entirely smooth. I have represented this character in the fragment fig. 1 *f*.

M. Cotteau has figured a large example of this species from the Upper Neocomian; from this we learn that age produces important modifications in the structure of the test; the poriferous zones are very wide, and bigeminal, not only on the upper surface, but as far down as the ambitus; besides the eight rows of primary tubercles there are some rudiments of secondary tubercles; the miliary zone is wide and depressed at the upper surface; the discal opening becomes more angular, and the ovarial plates penetrate

further into the ambulacral areas; the mouth-opening is circular, and the peristome nearly equally lobed.

Affinities and Differences.—*Pseudodiadema Malbosi* resembles some of the larger forms of *P. Brongniarti*, from the Grey Chalk of Folkestone, in the cabinet of my friend the Rev. T. Wiltshire, and figured in Pl. XX, fig. 2 *a*, *b*, in Pl. XXI B, fig. 3, and Pl. XXI A, fig. 2. The tubercles in *P. Brongniarti* are not so numerous in each row; the poriferous zones are narrower, and the bigeminal arrangement of the pores, so well developed in *P. Malbosi*, is less distinct in *P. Brongniarti*. These certainly are nearly allied species, and require a careful examination to detect the small differences existing between them.

P. Malbosi resembles *P. dubium*, Gras, from the same horizon. I have only a mould in plaster of the latter, not sufficiently sharp for scientific accuracy.

Locality and Stratigraphical Position.—The specimens I have figured were collected from the Lower Greensand at Whales Chine, Isle of Wight, in the Crioceras-beds that pass across that chasm, associated with *Ammonites Martini*, D'Orb., *Crioceras Bowerbankii*, Sow., *Gryphæa sinuata*, Sow., &c.

The specimens in the Museum of the Royal School of Mines were collected by Mr. H. B. Mackeson, from the Lower Greensand (Kentish Rag) of Hythe, and presented by him to that institution. Specimens are extremely rare in both the places quoted.

The foreign localities, according to M. Cotteau, are La Classe (Aude), Opoul (Pyrénées Orientales), where it is abundant in the Upper Neocomian beds, associated with *Echinospatagus Collegnii*, D'Orb.

B.—*Species from the Gault.*

PSEUDODIADEMA WILTSHIREI, *Wright*, nov. sp. Pl. XVI, figs. 1 *a*—*f*, 2, 3.

Test moderately large and equally depressed at both poles; ambulacral areas wide, with two rows of tubercles, large and approximated in the lower half of the area, small and detached in the upper; poriferous zones narrow, flexuous, pores in single file throughout; inter-ambulacral areas narrow, two rows of primary tubercles, and a few irregular secondary tubercles at the base of the area, primaries large and approximated in the lower half, small and remote above; miliary zone wide and finely granulated above, narrow and with large granules below; spines long and slender, the stem ornamented with delicate longitudinal lines.

Dimensions.—Height six tenths of an inch; transverse diameter an inch and a half.

Description.—We only possess a fragment of this beautiful form, still it has been enough to enable Mr. Bone to give a restoration of the test in Pl. XVI, fig. 1 *b*. The body is inflated at the sides, and nearly equally flattened on the upper and lower surface. The

ambulacral areas are wide and have two rows of tubercles; those on the lower portion of the area are large and closely set together, and those on the upper part are disproportionately small and placed widely apart (fig. 1 *b*); some very fine granules divide the large basal tubercles, and a numerous granulation surrounds the smaller tubercles on the upper part (fig. 1 *b*).

The inter-ambulacral areas possess only two rows of primary tubercles; those near the base are about the same size as the corresponding tubercles in the ambulacra, on the upper part of the area, they are larger, and diminish more gradually in size, so that the difference in the tubercles on the upper surface readily distinguishes the ambulacral from the inter-ambulacral areas; an irregular row of four small secondary tubercles occupies the outer side of the base between the primaries and the poriferous zones, and a like central row extends through the middle of the lower part thereof (fig. 1 *c*).

The miliary zone is wide and depressed in the upper part, and the plates are here covered with numerous small granules, that cluster chiefly around the bases of the small tubercles, the median sutural space being depressed and nude (fig. 1 *b*); the lower part of the zone is narrow, and the granules are much larger and more closely set together; many of them are raised on small mammillons, with secondary tubercles interspersed among them (fig. 1 *c*).

The large primary tubercles of both areas have very large areolas (fig. 1, *c*), with well defined margins. Each areola consists of two parts, an outer circle, consisting of a band covered with microscopic granules (fig. 1 *d*), and a smooth inner portion, from whence the boss arises (fig. 1 *e*). This kind of ornamention is very remarkable; it is very well preserved in the fragment before me, and correctly represented in figs. *d* and *e*. The summit of the boss is sharply crenulated, and the tubercle deeply perforated.

The spines were long and slender, as seen by some imprints on the slab (figs. 1, 2, 3); the acetabulum of the small head is marked by coarse crenulations, the milled ring is prominent, and the whole surface of the stem covered with fine longitudinal lines.

Affinities and Differences.—This species belongs to the group of which *P. Normaniæ* (Pl. XXI, fig. 3) may be regarded as the type. It differs from that species, however, in having smaller primary tubercles and fewer and smaller secondaries, in having narrower ambulacra and less flexuous poriferous zones. The miliary zone is likewise less distinctly marked; the general contour of the test is different, for the upper and lower surfaces are more depressed and the sides less inflated.

Locality and Stratigraphical Position.—This unique specimen was found by the Rev. T. Wiltshire, F.G.S., in the Gault at Folkestone, in a bed near the base of that formation. I have very great pleasure in dedicating this species to my kind friend as an acknowledgment of the important assistance he has rendered me during the progress of this work, by the generous contribution of all his best specimens for figuring, his able notes on certain species of Cidaris, and other valuable aid frankly given on all occasions when required.

c.—*Species from the Upper Greensand.*

PSEUDODIADEMA RHODANI, *Agassiz*. Pl. XVIII, figs. 3 *a—c*.

DIADEMA RHODANI,	*Agassiz*. Cat. Syst. Ectyp. foss., Mus. Neoc., Supplement, 1840.
— LUCÆ,	*Agassiz*. Idem, Mus. Neoc., p. 8.
— RHODANI,	*Agassiz*. Desc. des Échinid. foss. de la Suisse, tom. ii, p. 9, pl. xvi, figs. 16—18, 1840.
— LUCÆ,	*Agassiz*. Idem, p. 8, pl. xvi, figs. 11—15, 1840.
— —	*Agassiz* and *Desor*. Cat. Raison. des Échinid., Ann. des Science Nat., 3e sér., t. vi, p. 346, 1846.
— RHODANI,	*Agassiz* and *Desor*. Idem.
— LUCÆ,	*Bronn*. Index Palæontologicus, p. 418, 1848.
— RHODANI,	*Bronn*. Idem, p. 419.
— LUCÆ,	*Albin Gras*. Oursin. foss. de l'Isère, p. 33, 1848.
— —	*D'Orbigny*. Prodrome de Paléontol. strat., t. ii, p. 142, Ét. 19, 1850.
— RHODANI,	*Renevier*. Mém. Géol. sur la Perte du Rhone, p. 49, 1853.
— —	*Morris*. Catalogue of British Fossils, 2nd ed., p. 70, 1854.
— —	*McCoy*. Mesozoic Radiata, p. 67, 1854.
PSEUDODIADEMA LUCÆ,	*Desor*. Synopsis des Échinides fossiles, p. 71, 1855.
— RHODANI,	*Desor*. Idem, p. 71.
DIADEMA —	*Pictet*. Traité de Paléontol., 2e ed., t. iv, p. 244, 1857.
— LUCÆ,	*Pictet*. Idem.
— DESORI,	*Forbes*. Notes by S. P. Woodward; Memoirs of the Geol. Surv., Decade V, p. 8, 1856.
— PUSTULATUM,	*Forbes*. Idem, p. 8, 1856.
PSEUDODIADEMA LUCÆ,	*Dujardin* et *Hupé*. Hist. Nat. des Zoophytes, Échinodermes, p. 498, 1862.
— RHODANI,	*Dujardin* et *Hupé*. Idem.
— —	*Cotteau*. Paléontol. Française, Terrain Crétacé, p. 460, pl. 1110, 1864.

Diagnosis.—Test circular, depressed, slightly convex above, very concave beneath, a little inflated at the angles; ambulacral areas with two complete rows of tubercles, fourteen to fifteen in each, and three incomplete rows of small secondary tubercles at the base, five or six in each; inter-ambulacral areas with two rows of primary tubercles, thirteen or fourteen in each, and four rows of small unequal secondary tubercles at the base; primary tubercles large at the ambitus, suddenly diminishing in size in both areas on the

upper and under surface; plates covered with a fine uniform granulation; mouth-opening situated in a concave depression.

Dimensions.—Transverse diameter one inch and one tenth of an inch, height half an inch.

Description.—Although this Diadema exhibits a group of well-marked specific characters, its history, nevertheless, is involved in much confusion, from want of a careful examination of the anatomy of the shell.

The prominent ambital tubercles in the inter-ambulacra, their sudden diminution in size on the upper surface, with the baldness of the test in that region, and the crowding of the base with small tubercles nearly uniform in size, form a group of persistent characters which distinguish *Pseudodiadema Rhodani* from all its congeners.

The smaller forms of this species were figured and described by Professor Agassiz as *Diadema Lucæ*, and the large tests as *Diadema Rhodani*. A series of specimens, of different ages, has since shown that these two forms are identical.

This initial error introduced the confusion that followed, and has rendered it a matter of some difficulty to understand the synonyms of this species; the careful study of a good type form sent by the late M. Sæmann from the Gault (Étage Albien, d'Orbigny) of Clars, near Escragnolle, department of the Var, has enabled me to compare our English examples with an undeniable specimen, and from this examination to determine that *Diadema Desori*, Forb., and *D. pustulatum*, Forb., are different forms of *Pseudodiadema Rhodani*. My late esteemed colleague Dr. S. P. Woodward adopted Professor Forbes's materials in his "Notes on British Fossil Diadems," contributed to Decade V of the 'Memoirs of the Geological Survey;' and it is evident from these notes that he had his doubts as to the accuracy of our lamented friend's determinations, as will appear in the description of the different species.

There are two varieties of *Pseudodiadema Rhodani*—a large form, identical with the type, figured by Agassiz,[1] and a smaller form, corresponding with *P. Lucæ*. The former I have obtained from the Chloritic Marl of Chard; the latter from the Upper Greensand of Warminster, where it appears to be rare. The fine example figured in Pl. XVIII, fig. 3, *a*, *b*, *c*, is of moderate size; the test is circular and depressed, slightly convex above, inflated at the sides, and very concave below; the ambulacral areas are large, and a little expanded at the sides to give increased space to the ambital tubercles; from this point they taper regularly towards both poles. There are two rows of primary tubercles, from sixteen to seventeen in each, extending from the peristome to the disc; three of these in each row, at the ambitus, are large, and all those on the upper surface small, diminishing to mere granules near the disc (fig. 3 *a*); the tubercles on the under surface are small, and have a uniform size to the peristome; in this region the area is filled in with several smaller secondary tubercles (fig. 3 *b*). The poriferous zones are slightly undulated at the

[1] 'Description des Échinodermes fossiles de la Suisse,' tab. xvi, figs. 16—18, p. 9.

sides and base; they are composed of simple oval pores arranged in single file throughout (fig. 3 *d*). The inter-ambulacral areas one half wider than the ambulacral, have two rows of primary tubercles, fourteen to fifteen in each; a little larger at the ambitus and upper surface than in the ambulacra; three pairs are much larger at the sides, those on the upper surface diminish rapidly in size between the ambitus and disc; and on the under surface they are small and nearly uniform in structure. Between the basal angle and the peristome there are short rows of secondary tubercles, about the size of the primaries in this region, with a few scattered secondaries between the lateral rows; as all these small tubercles are nearly the same size, the under surface of the test has a highly ornamented appearance—the inter-ambulacra with four, and the ambulacra with two rows of small, uniform tubercles, and several secondary ones planted at every interval on the plates (fig. 3 *b*). On the upper surface the six upper tubercles are small, diminishing to mere granules around the discal opening (fig. 3 *c*). The large ambital tubercles are surrounded by shallow circular areolas (fig. 3*d*). In some specimens they are confluent, in others separated by one or two rows of minute granules. The small dorsal tubercles are surrounded by ring-like areolas, and the basal tubercles have a chain-like arrangement of granules encircling them, which adds to the ornamentation of this region. The miliary zone is very large; from the sides to the discal aperture the entire surface of the plates of both areas, except those portions occupied by the areolas, is covered with small, numerous, close set of granules, which form divisional partitions on each side of the mesial sutures between the rows of the primary tubercles, and then expand into a regular corrugation on all the upper surface, the dwarfing of the tubercles being compensated by an increased development of granular ornamentation on this region of the test. The base is very concave, and the small, circular peristome, indented with well-marked entailles, is situated at the bottom of a deep depression; the entire surface of the base is studded with small tubercles, surrounded with the circles of granules already described. The disc is absent in all the specimens hitherto found; the opening is large and pentagonal, indicating a great development of this structure in the species.

Affinities and Differences.—*P. Rhodani* is readily distinguished from its congeners by the subundulated poriferous zones, small dorsal, intermediate basal, and large primary ambital tubercles, by the shortness of the secondary rows limited to the base, by the smallness of the dorsal tubercles and the fine homogeneous granulation on the miliary zone; the concavity of the base, smallness of the peristome, and depth at which it lies, added to the highly ornamented character of the plates, form a group of characters that readily distinguish it from all others. It resembles most *P. Normaniæ* (Pl. XXI, fig. 3), from the Grey Chalk of Folkestone, in the varied development of the tubercles in each row; the *ensemble* of the test in the latter form is sufficiently defined by good specific characters, and for the definition of these I must refer to the article on that species.

Locality and Stratigraphical Position.—The large example I have figured was found

in the Chloritic Marl, full of green specks of iron, at Chard, associated with *Catopygus carinatus*, Goldf., *Discoidea subuculus*, Leske, *Pseudodiadema ornatum*, Goldf., *P. variolare*, Brong., with *Ammonites splendens*, Sow., *A. varians*, Sow., and other forms characteristic of the Upper Greensand formation. The specimens from Warminster, in the Museum of the Royal School of Mines, and in the Collections of Mr. Soper and Mr. Cunnington, Devizes, were found in the Upper Greensand with *P. Michelini*, Agas., and *P. Benettiæ*, Forb., and other common Upper Greensand forms, as *Catopygus carinatus*, Goldf., *Salenia petalifera*, Agass., and *Goniopygus peltatus*, Agas., &c. &c.

Foreign Distribution.—Geraudot (Aube); Pérte du Rhône (Ain); Clars, Escragnolle (Var); very common in the Étage Albien (Cotteau).

History.—First figured by Professor Agassiz in 1840, the large forms as *Diadema Rhodani*, the smaller as *D. Lucæ*. After much confusion it was discovered that these forms are identical. Professor Forbes, from not possessing types of *Pseudodiadema Rhodani*, named the large form *Diadema pustulatum*, and the small ones from Warminster *D. Desori;* this nomenclature was adopted by Dr. S. P. Woodward, in 1856, in his "Additional Notes on British Fossil Diadems," published in Decade V of the 'Memoirs of the Geological Survey.' M. Cotteau, in 1863, has given admirable figures, and a most correct description of the species, which my observations confirm in all their details.

PSEUDODIADEMA MICHELINI, *Agassiz.* Pl. XIX, figs. 2, *a—f.*

DIADEMA MICHELINI,	*Agassiz.* Catal. Syst. Ectyp. foss. Mus. Neoc., p. 8, 1840.
— —	*Agassiz* et *Desor.* Catal. rais. des Échinides, Ann. Sc. Naturelles, 3e sér., t. vi, p. 347, 1846.
— —	*Bronn.* Index Palæont., p. 418, 1848.
— —	*Sorignet.* Ours. foss. de dép de l'Eure, p. 25, 1850.
— —	*D'Orbigny.* Prod. Paléont. strat., t. ii, p. 179, 1850.
— BONEI,	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 76, 1854.
— —	*Woodward.* Mem. of Geol. Survey, Decade V, explan. of pl. ii, 1856.
PSEUDODIADEMA MICHELINI,	*Desor.* Synopsis des Échinides fossiles, p. 72, 1856.
DIADEMA MICHELINI,	*Pictet.* Traité de Paléont., 2e éd., t. iv, p. 245, 1857.
PSEUDODIADEMA PULCHELLUM,	*Cotteau.* Échinides nouv. ou peu connus (Revue de Zoologie), p. 3, pl. i, fig. 7—9, 1857.
PSEUDODIADEMA MICHELINI,	*Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Echinoderm., p. 499, 1862.
— —	*Cotteau.* Paléontologie Française, Terrain Crétacé, p. 476, pl. 1114, 1864.

Diagnosis.—Test circular, or slightly pentagonal, depressed; base flat, inflated at the margin, concave towards the mouth; ambulacral areas large, two rows of prominent

primary tubercles, 12—14 in each row; interambulacral areas with two rows of primary tubercles, 12—14 in a row, and two external rows of small secondary tubercles, extending from the peristome to the ambitus; mouth-opening small, in a concave depression; tubercles of both areas nearly the same size.

Dimensions.—Height six tenths of an inch; transverse diameter one inch and one fifth.

Description.—This Urchin is in general of medium size, with a sub-circular or pentagonal test, convex above and flat below; the ambulacral areas are large, slightly inflated, and provided with two rows of small primary tubercles, 12—14 in a row, rather less than those in the interambulacral areas, and separated by a double zigzag row of very small granules (fig. 2 *d*), gradually diminishing in size from the ambitus to both poles; the poriferous zones are subflexous and composed of pairs of small round holes placed in single file throughout, crowded together near the peristome, and spread out above; the inter-ambulacral areas are twice the width of the ambulacral and furnished with two rows of primary tubercles rather larger than those of the ambulacral areas; they are very uniform in size and gradually diminish from the ambitus to the poles; between these rows and the poriferous zones, and between the two rows themselves, a series of small tubercles, 6—8 in number, extends from the peristome to the ambitus, where they disappear; these small secondary tubercles fill up the intertubercular spaces at the base, and give the under surface of the test a very ornamental appearance (fig. 2 *b*). There are fourteen plates in each column of the inter-ambulacra, the primary tubercle occupying the centre of each; the areolas are circular and superficial, the bosses prominent and sharply crenulated, and the mammillons large and deeply perforated (fig. 2 *d*); the surface of the plates is sparsely covered with small granules which form circles around the areolas and are scattered without order over the interspaces; the internal borders of the four uppermost plates of both columns are nude (fig. 2 *b*); and the sutures distinctly visible throughout their entire course. The ambulacral areas have fourteen plates in each column, the tubercles are rather smaller than those in the inter-ambulacra, and the narrow areolas are separated by a zigzag line of single granules (fig. 2 *f*), which becomes double (fig. 2 *d*) near the ambitus. The miliary zone is large, nude, and depressed at the upper part, granular towards the equator, and narrow and sinuous as it approaches the peristome (fig. 2 *c*).

The mouth-opening is small, and lodged in a deep depression, the basal portion of the test being inflated around the peristome, which is decagonal, with nearly equal lobes (fig. 2 *b*).

The apical disc is absent in all the specimens I have examined; the opening, however, is large, a little elongated, subpentagonal, and angular (fig. 2 *a*).

Affinities and Differences.—This Urchin is distinguished from its congeners by its inflated base, depressed upper surface, simple pores, numerous primary tubercles nearly uniform in size and number in the columns of both areas, by its small unequal secondary tubercles,

extending at the base between the primaries and the poriferous zones, and by its narrow peristome sunk in a deep depression; a careful comparison of typical specimens of *Diadema Michelini*, Ag., from the Upper Greensand of Villers-sur-Mer, Calvados, kindly sent by M. Michelin, has satisfied me that *Diadema Bonei*, Forb., is identical with *D. Michelini;* and that *P. Benettiæ*, Forb. (Pl. XV, fig. 2), both as regards its general form, the number, disposition, and character of its primary and secondary tubercles, the smallness of the mouth-opening, situated in a deep depression, and the equal lobes of the peristome, is identical with some forms of *P. Michelini* of the same size.

Locality and Stratigraphical Position.—This species is very common in the Upper Greensand near Warminster; the smaller forms are very closely allied to the *Diadema Benettiæ*, Forb., the larger to the *D. Bonei*, Forb.; it has likewise been found in the same formation at Durdle Cove, Dorset.

Foreign Localities.—It has been collected from the Étage Cénomanien of France (= Upper Greensand) at Villers-sur-Mer, Cauville, Vaches-Noires, Saint-Jouin (Calvados); Octeville (Manche); Fécamp, Orcher, Le Havre, Rouen (Mont-St.-Catherine), Seine-Inférr.; Vimoutiers, Gracè (Orne); Présagny (Eure).

Pseudodiadema Benettiæ, *Forbes.* Pl. XV, figs. 2, *a—f.*

Diadema Benettiæ, *Forbes.* Morris, Cat. Brit. Foss., 2nd ed., p. 76, 1854.
— — *Woodward.* Memoirs of the Geol. Surv., Decade V, p. 7, 1856.
Pseudodiadema Benettiæ, *Desor.* Synopsis des Échinides fossiles, p. 72, 1858.
— — *Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Échinodermes, p. 499, 1862.
— Michelini, *Cotteau* (pars). Paléontologie Française, Terrain Crétacé, p. 476, 1864.

Test circular, inflated, depressed; ambulacral areas wide, with two rows of tubercles 15 in each, separated by a double row of minute granules; inter-ambulacral areas with two rows of primary tubercles, 14 in each; separated by a wide median space, unequally granulated; miliary zone smooth above; a few small secondary tubercles at the base; primary tubercles of both areas nearly of the same size. Peristome very small, deeply sunk in a concave depression; discal aperture large and pentagonal.

Dimensions.—Transverse diameter one inch; height four tenths of an inch.

Description.—This beautiful little Urchin was formerly considered to be the *Diadema ornatum*, Goldf., and recorded as such in the first edition of Morris's 'Catalogue of British Fossils.' It was subsequently considered by Professor Forbes to be a distinct species, and in the second edition of that work was dedicated by him to the late Miss

E. Benett, of Norton House,[1] Wilts. It was first accurately described by the late Dr. Woodward in his Notes on Fossil Diadems.

The test is circular, depressed on the upper surface, concave below, and inflated at the sides. The ambulacral areas are proportionally wide, with two rows of tubercles separated by a double row of granules; there are from 12—15 in each row, according to age; they increase gradually in size, from the peristome and disc towards the ambitus, where they are largest; the poriferous zones are narrow and slightly undulated; the pores are in oblique single file throughout, three pairs of holes being opposite each ambulacral plate (fig. 2 *a*), where they are magnified four diameters; the pores at the circumference have a small tubercle between each pair; the inter-ambulacral areas are about one fourth part wider than the ambulacral; they have two rows of tubercles, from 12—14 in each, separated by a wide miliary zone, which is unequally granulated, and becomes smooth on the upper surface; a similar sparsely granulated space separates the tubercles from the poriferous zones; and at the base of the area a short row of small secondary tubercles extends from the peristome to the angle, between the large tubercles and the poriferous zones. The tubercles of both areas are nearly of the same size, those of the inter-ambulacral are the largest; they have all distinct oval areolas, which are sometimes radiated, and encircled by rows of very small granules. The base is inflated at the circumference, and concave in the middle; the peristome is small and deeply sunk, about one third the diameter of the test; its margin is divided by feeble entailles. The disc is absent in all our specimens; the aperture is wide and pentagonal, the angles pointing towards the median suture of the inter-ambulacral areas.

Affinities and Differences.—This species so much resembles *Pseudodiadema Michelini*, Ag., that it has been considered by some authors to be the same. M. Cotteau says, "*P. Michelini*, such as we understand it, cannot be distinguished from *P. Benettiæ*, Forb., and we do not hesitate to unite the two species, which present in their form, in the disposition of their tubercles, in the structure of their peristome, in a word, in the ensemble of their characters, an identity almost complete." Admitting, as I do, the great similarity of the tests of the two forms, still I think, by a careful study of both, we can detect characters which may justify us in retaining our lamented colleague's species. *P. Benettiæ* has the tubercles smaller, the sides more inflated, the circumference of the base more convex, and the mouth-opening smaller and lodged in a deeper depression. *P. Michelini* is a flatter Urchin, and the size and greater prominence of the tubercles impart to it a more spinous character; if these points of difference in the test are borne out by any corresponding difference in the spines, the species may be sustained; if not, *P. Bennetiæ* may turn out to be a mere variety of *P. Michelini*.

Locality and Stratigraphical Position.—This is a very abundant species in the junction-beds of the Upper Greensand at Warminster, associated with *P. Michelini*,

[1] Authoress of 'A Catalogue of Wiltshire Fossils,' 1831.

Catopygus carinatus, and the other species of this zone. It has been collected from the same beds at Durdle Cove, on the Coast of Dorset.

Foreign Distribution.—M. Desor states that *P. Benettiæ* is found in the Craie chloritée (Cénomanien) of Villers-sur-Mer, Vaches-noires, de Gacé, Orne, and is common in all French collections.

D. *Species from the Grey Chalk.*

PSEUDODIADEMA ORNATUM, *Goldf.*, sp. Pl. XVI, figs. 4 *a—e*; Pl. XIX, figs. 1 *a—c*; Pl. XXI, figs. 1 *a—d*, 2; Pl. XXI A, figs. 1 *a*, *b*.

CIDARITES ORNATUS,	*Goldfuss.* Petref. Germaniæ, tab. xl, fig. 10, p. 123, 1826.
DIADEMA ORNATUM,	*Agassiz.* Prod. d'une Monogr. des Radiares, Mém. Soc. des Sc. Nat. de Neufchatel, t. i, p. 118, 1836.
— —	*Desmoulins.* Études sur les Échinides, p. 314, No. 15, 1837.
— —	*Dujardin.* In Lamarck's Anim. sans Vertébres, 2e éd., t. iii, p. 392, 1840.
— —	*Roemer.* Norddeutschen Kreidegebirges, p. 29, 1840.
— —	*Agassiz* et *Desor.* Catalogue raison. des Échinides, Ann. Sc. Nat., 2e sér., t. vi, p. 347, 1846.
— —	*Bronn.* Index Palæont., p. 449, 1848.
— —	*D'Orbigny.* Prod. de Paléont. strat., t. ii, p. 169, Ét. 20, No. 560, 1850.
— —	*Forbes.* In Morris's British Fossils, 2nd ed., p. 77, 1854.
— —	*McCoy.* Contributions to Brit. Palæontology, p. 67, 1854.
— —	*Desor.* Synopsis des Échinides fossiles, p. 72, 1856.
— —	*Woodward.* Mem. of Geol. Surv., Decade V, p. 7, 1856.
— TUMIDUM,	*Woodward.* Mem. Geol. Surv., Decade V, 1856.
— CARTERI,	*Woodward.* Ibid.
PSEUDODIADEMA ORNATUM,	*Pictet.* Traité de Paléontol., 2e éd., t. iv, p. 245, 1857.
— —	*Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Échinod., p. 499, 1862.
— —	*Cotteau.* Paléontologie Française, Terrain Crétacé, pl. 1115, tom. ii, p. 480, 1864.

Test circular, inflated; ambulacral areas straight; tubercles small, numerous, subequal, in two rows, separated by a double series of granules; inter-ambulacral areas with two rows of tubercles, separated by four rows of granules at the ambitus, which disappear at the upper surface, and leave a smooth depressed space in the middle of the miliary zone, bordered by two rows of granules; between the tubercles and poriferous zones a row of secondary tubercles extends from the peristome to near the disc, consisting of small well-spaced-out tubercles, each surrounded by a circle of granules. Areolas circular, many of them radiated; tubercles of both areas nearly equal in size.

Dimensions.—Height half an inch; transverse diameter one inch and two tenths.

Description.—This beautiful Urchin when full grown is moderately large; it has a circular, elevated, and inflated form, depressed on the upper surface, and concave beneath.

The ambulacral areas are large, a little inflated, and furnished with two rows of moderately sized tubercles, 14—16 in a row; one of these is always longer than the other, and separated from its fellow by a double series of small compact granules. The poriferous zones are straight and narrow at the base of the test, and gently subundulated from the ambitus to the apical disc; they are composed of simple pores closely approximated to each other; the pairs are well spaced out in the infra-marginal region, closer together at the equator, and still closer placed near the disc. Pl. XXI, figs. 1 *b*, *c*.

The inter-ambulacral areas are large, and provided with two rows of tubercles, nearly identical in size with those of the ambulacral areas at the base and ambitus of the same regions; in the upper part of the area, however, they are proportionally larger, so that we find only 13—15 tubercles in each row. The secondary tubercles form a distinct series of from seven to nine small tubercles, situated between the primary row and the poriferous zones; in general one small tubercle arises from each plate between the peristome and ambitus (Pl. XIX, fig. 1 *d*), and is absent from the three or four upper plates of the test (Pl. XVI, fig. 4 *e*); besides these, there are other smaller tubercles, of unequal size, scattered between the primary and secondary rows (Pl. XIX, figs. 1 *b*, *c*, *d*).

The miliary zone is very wide; it is narrow near the peristome, enlarged at the ambitus, and nude and depressed on the upper surface (Pl. XVI, figs. 4 *c* and *e*). The granules are numerous, unequal, sometimes mammillated, and distinguished with difficulty from the small secondary tubercles among which they are interspersed (Pl. XXI, figs. 1 *a*, *c*; Pl. XVI, figs. 4 *c*, *d*).

The primary tubercles of both areas have well-defined circular areolas, prominent bosses, with sharply crenulated summits, and large mammillons with deeply drilled summits; the inter-ambulacral are a little larger than those of the ambulacral areas. The areolas near the ambitus are mostly confluent above and below, whilst on the upper surface of the inter-ambulacra they are distinct, and surrounded by circles of small granules (Pl. XXI, fig. 1 *c*.).

The under surface is convex at the circumference, with a deep depression in the middle, in which the mouth-opening is situated. The peristome is very small, and its margin feebly indented. The discal opening is large, elongated, and sub-pentagonal. Unfortunately, all the specimens hitherto found want the discal plates (Pl. XIX, fig. 1 *b*).

Affinities and Differences.—This Urchin resembles *P. Michelini*; it is, however, distinguished from that species by its much greater height, inflated sides, narrow base, slightly undulated poriferous zones, more numerous and better developed secondary tubercles, more deeply sunk peristome, and elongated discal opening; these diagnostic characters are not the result of age, as they are observed more or less in comparing young specimens of both species apparently of the same age with each other.

Locality and Stratigraphical Position.—The specimens figured, from the Grey Chalk, Folkestone, on Pls. XVI, XIX, and XXI A, belong to the Rev. T. Wiltshire, the

British Museum, and my cabinet. I have examined a specimen from the Red Chalk of Hunstanton Cliff, belonging to my friend C. B. Rose, Esq., F.G.S., who has most kindly communicated many of his Echinodermata for this work. The specimen figured in Pl. XXI, fig. 1, now in my cabinet, was collected from the remarkable bed of Chloritic Marl at Chard, which has yielded so many fine examples of *Echinidæ*. The specimen in the Cambridge Museum is recorded by Professor McCoy as having been collected from the Upper Greensand of Blackdown. Many of the specimens sent me as *P. Carteri* by my friend Mr. J. Walker, F.G.S., and collected by him from the coprolite beds of the Upper Greensand near Cambridge, are undeniable specimens of *P. ornatum*.

Foreign Distribution.—France.—Rouen, Mountain of St. Catherine, Seine-Inférieure; Vimoutiers (Orne), in the Étage Cénomanien, where it is rare. *Germany.*—Essen-on-the-Ruhr, Westphalia, whence Goldfuss's type specimen was obtained.

History.—This Urchin was first figured and described in the 'Petrefacta Germaniæ' by Goldfuss, in 1826, under the name *Cidarites ornatus*. Professor Agassiz, in 1836, erroneously referred to this species a small Neocomian form, which was subsequently separated under the name *Diadema Bourgueti*. In the first edition of the 'Catalogue of British Fossils,' *Diadema Benettiæ* was recorded as *D. ornatum* on the authority of Dr. Woodward. Professor Forbes named the tumid varieties of this Urchin *Diadema tumidum*, and under this name they are described, from type specimens, in my cabinet (Pl. XXI, fig. 1), by Dr. S. P. Woodward, in his "Notes on British Fossil Diadems," contributed to Decade V, 'Memoirs of the Geological Survey.'

PSEUDODIADEMA NORMANIÆ, *Cotteau*, 1863. Pl. XXI, fig. 3, *a*, *d*.

PSEUDODIADEMA NORMANIÆ, *Cotteau*. Paléontologie Française, Terrain Crétacé, t. vii, p. 468, pl. 1112.

Test of moderate size, subcircular, inflated at the sides, and convex above; base rounded at the margin, and very concave in the centre; ambulacral areas wide, with two rows of tubercles, large at the ambitus and small on the upper and infra-marginal regions, separated by several rows of minute unequal granules; inter-ambulacral areas narrow, with two rows of primary tubercles, nearly similar in size and development to those of the ambulacra, and numerous small, unequal, secondary tubercles, forming in the infra-marginal region six short series, two on each side, and two in the middle of the primary rows; mouth-opening lodged in a deep depression.

Dimensions.—Height six tenths of an inch; transverse diameter one inch and four tenths.

Description.—This rare and beautiful Urchin is of medium size; it has a subcircular form, with broad inflated sides, convex at the upper surface and very concave beneath. The ambulacral areas are wide in the middle, lanceolate in the upper part, and narrow in the infra-marginal region; they have two rows of primary tubercles, of which two pairs at the

ambitus are very largely developed, and occupy the greatest part of the area, having large areolas, prominent bosses, sharply crenulated summits, with projecting, deeply perforated mammillons (Pl. XXI, fig 3 *d*); on the upper surface they rapidly diminish in size; four of them have small areolas and the others become mere granules. In the infra-marginal region they gradually diminish as they approach the peristome, where two short rows of secondary tubercles are regularly arranged. The primary tubercles are separated by two rows of very fine granules, which gradually increase in number, and fill the entire upper portion of the area (fig. 3 *d*).

The poriferous zones are narrow and straight at the base, undulated on the sides, and straight again on the upper surface; the pores are simple, round, largely open, and arranged in a single file throughout (fig. 3 *c* and *d*).

The inter-ambulacral areas are relatively small from the excessive width of the ambulacra; they have two rows of primary tubercles, of which three pairs at the ambitus, like those in the ambulacral areas, attain a great development; above they become suddenly smaller, and diminish to mere granules; and on the infra-marginal region they become gradually smaller as they approach the peristome. The secondary tubercles are very abundant, and limited to this region of the test; at the base of each interambulacra there are six short rows, a long and a short row between the zones and the tubercles on each side, and two short rows between the tubercles themselves. This great profusion of small secondary tubercles and diminished size of those in the primary series impart to the base of the test of this Urchin a remarkable ornamental appearance, which resembles, on a larger scale, the structure of the base in *P. Rhodani* (fig. 3 *b*).

The miliary zone is largely developed; the two primary rows of tubercles at the ambitus have six rows of granules forming a band between them; in the upper part the granulation increases, and fills the whole zone, except the part occupied by the areolas of the small rudimentary tubercles, forming circles around them, and filling the whole space with a fine nearly uniform granulation.

The base is very concave and crowded with small tubercles; the mouth-opening is small, and lies at the bottom of a very deep depression; the peristome is narrow, and marked by feeble indentations.

Affinities and Differences.—This remarkable species resembles *P. Rhodani* in having its base crowded with numerous small tubercles, and in having large tubercles at the ambitus, and rudimentary ones on the upper surface. Its form, however, is always inflated; the poriferous zones are straight at the base and upper surface, and undulated at the ambitus. The secondary tubercles are larger and more numerous, and distinguished with difficulty from those of the primary rows of the under surface.

Locality and Stratigraphical Position.—The only specimen I have seen was obtained from the Grey Chalk near Folkestone by the Rev. T. Wiltshire, to whose cabinet it belongs.—*Foreign Distribution.*—M. Cotteau records Vimoutiers (Orne), in the Étage Cénomanien, where it is very rare.

PSEUDODIADEMA VARIOLARE, *Brongniart*, sp., 1822. Pl. XVII, figs. 1—5; XVIII, figs. 1, 2.

CIDARITES VARIOLARIS,	*Brongniart.* Géog. phys. des env. de Paris, pl. v, fig. 9, 1822; Tableau des Terrains, p. 408, 1829; Desc. géol. des env. de Paris, 3e édit., pl. xvii, fig. 9, 1835.
DIADEMA VARIOLARE,	*Agassiz.* Prod. d'une Monogr. des Radiaires, p. 189, 1836.
CIDARITES VARIOLARIS,	*Roemer.* Norddeutschen Kreidegebirges, p. 29, 1840.
DIADEMA VARIOLARE,	*Morris.* Catalogue of British Fossils, p. 51, 1843.
— —	*Agassiz* et *Desor.* Catalogue rais. des Échinides, Ann. des Sc. Nat., 3e sér., t. vi, p. 350, 1846.
— SUBNUDUM,	*Agassiz* et *Desor.* Ibid.
— ROISSYI,	*Agassiz* et *Desor.* Ibid.
TETRAGRAMMA VARIOLARE,	*Bronn.* Index Palæontologicus, p. 1261, 1848.
DIADEMA —	*A. Gras.* Oursins foss. de l'Isère, p. 33, pl. ii, fig. 16, 1848.
— SUBNUDUM,	*D'Orbigny.* Prod. de Paléont. strat., t. ii, p. 179, 1850.
— ROISSYI,	*D'Orbigny.* Ibid., t. ii, p. 201.
TETAGRAMMA SUBNUDUM,	*Sorignet.* Ours. foss. de l'Eure, p. 26, 1850.
CIDARIS VARIOLARIS,	*D'Archiac.* Hist. des progrès de la Geol., t. iv, p. 215, 1851.
DIADEMA VARIOLARE,	*Quenstedt.* Handbuch der Petrefaktenkunde, p. 580, 1852.
TETRAGRAMMA —	*Giebel.* Deutschlands Petrefacten, p. 319, 1852.
DIADEMA SUBNUDUM,	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 77, 1854.
— VARIOLARE,	*Forbes.* Ibid.
DIPLOPODIA VARIOLARIS,	*Desor.* Synopsis des Échinides fossiles, p. 78, 1856.
— SUBNUDA,	*Desor.* Ibid.
— ROISSYI,	*Desor.* Ibid.
DIADEMA VARIOLARE,	*Woodward.* Mem. Geol. Survey, Decade V, 1856.
— SUB-NUDUM,	*Woodward.* Ibid.
— —	*Pictet.* Traité de Paléont., 2e éd., t. iv, p. 245, 1857.
— ROISSYI,	*Pictet.* Ibid.
DIPLOPODIA VARIOLARIS,	*Coquand.* Synop. des Foss. Crétacés, Bulletin Soc. Géol. de France, 2e sér., t. xvi, p. 992, 1859.
— SUBNUDUM,	*Coquand.* Ibid.
PSEUDODIADEMA STRIATULUM,	*Cotteau* et *Triger.* Échin. du départ. de la Sarthe, p. 144, pl. xxxvii, figs. 13—15, 1859.
PSEUDODIADEMA ROISSYI,	*Cotteau* et *Triger.* Ibid.
DIPLOPODIA VARIOLARIS,	*Coquand.* Cat. rais des Foss. départ. Charente, p. 155, 1861.

DIPLOPODIA SUBNUDUM, *Coquand.* Ibid.
— VARIOLARIS, *Dujardin* et *Hupé.* Hist. Nat. des Zooph. Échinodermes, p. 501, 1862.
— SUBNUDA, *Dujardin* et *Hupé.* Ibid.
— STRIATULUM, *Dujardin* et *Hupé.* Ibid.
PSEUDODIADEMA VARIOLARE, *Cotteau.* Paléontologie Française, Terrain Crétacé, t. vii, p. 488, pls. 1117, 1118, 1119, and 1120, figs. 1—3, 1864.

Test large, subcircular, slightly subpentagonal, nearly equally depressed on the upper and under surfaces. Ambulacral areas narrow and contracted at the upper part by the poriferous zones; two rows of tubercles, 15—17 in each series, separated by a single line of granules; pores round, in oblique single pairs in the middle, widely bigeminal on the upper surface, and trigeminal near the peristome. Inter-ambulacral areas wide, with four rows of primary tubercles and two short rows of small secondary tubercles. The middle of the upper surface of the area nude and often depressed. Under surface convex, mouth-opening small; peristome with feeble entailles. Discal opening large, sharply angular, pentagonal.

Dimensions.—A.—Height half an inch; transverse diameter one inch. B.—Height half an inch; transverse diameter one inch and a half.

Description.—The identity of this species has long been uncertain from the impossibility of ascertaining the Urchin intended by the figure and description given by Brongniart, without reference to the type specimen; this comparison has now fortunately been made by M. Cotteau, who has given admirable figures and most ample descriptions of the various forms *P. variolare* exhibits under different conditions of age and habitat. I shall first describe the general characters of the species, and secondly point out the three chief varieties it assumes.

The test is of medium size, subcircular, sometimes lightly pentagonal, and equally depressed at both poles. The ambulacral areas are narrow, and contracted at their upper part by the excessive development of the poriferous zones in this region; they possess two rows of large tubercles, 15—17 in each series, according to size and age, which gradually diminish in size from the equator to the peristome, and become small and rudimentary on the upper surface (Pl. XVII, fig. 3 *a*). The rows are closely approximated, there being only a single series of small granules, of unequal size, forming a zigzag line, between them; the tubercles have narrow areolas, prominent bosses, with sharply crenulated summits, and deeply perforated mammillons (fig. 4). The poriferous zones are narrow, the pores round, in single oblique pairs on the sides, in triple oblique pairs near the peristome, and they are widely bigeminal in all the upper fourth of the zones (fig. 5 *a*).

The interambulacral areas are nearly four times as wide as the ambulacral in the specimen figured in Pl. XVII, figs. 3 *a*, *b*, *c*, rather more than one inch in diameter. There are four rows of large tubercles, and two secondary rows, at the ambitus; the two inner primary rows, with fourteen tubercles in each series, extend from the peristome to the apical

disc, and the outer primary rows are absent from the three uppermost plates (fig. 3 *a*). In a large specimen from the Chalk-Marl of Dorset, B, one and a half inches in diameter, the ambital plates have six and eight rows of large tubercles, and two rows of small secondary tubercles. There are sixteen tubercles in each inner series which alone reach the disc, the second, third, and fourth rows disappear as the plates shorten on the upper surface. The small secondary tubercles, situated near the poriferous zones, form a short series between the peristome and equator; they are scarcely larger than granules, but are, nevertheless, mammillated and perforated, and their presence, position, and development, constitute one of the specific characters of this Urchin. The interambulacral tubercles are nearly identical in size with those of the ambulacral areas (fig. 4). They have narrow areolas, prominent bosses, with sharply crenulated summits, and large perforated mamillons. The miliary zone is narrow at the sides and infra-margin, with two rows of granules of unequal sizes; at the upper surface it becomes nude and depressed (fig. 3 *a*) around the discal opening, a character which appears in excess in the var. *subnudum*. A number of granules, of different sizes, form hexagonal circlets around the areolas (fig. 5 *a*).

The under surface is convex, and the small mouth-opening occupies a slight depression; the peristome is circular, and its margin notched with feeble entailles (fig. 3 *b*). The opening for the apical disc was very large (fig. 3 *a*), widely pentagonal, and sharply angular, extending into the nude portion of the inter-ambulacra. None of the specimens as yet found contain any of the discal plates. (See likewise Pl. XVIII, figs. 1 *a*, *b*, and fig. 2).

Authors have recognised three distinct forms of this species, which some have described as so many separate species, whilst others regard them as varieties of one.

1st. Var. *a*, *variolare*, identical with Brongniart's type form, is found in the Upper Greensand of Wiltshire and the "Chloritic Marl" of Chard (Pl. XVIII, fig. 2) and l'Étage Cénomanien of Villers-sur-Mer, Calvados, France, from which localities I have specimens. Its upper surface is more or less depressed, and its outline is circular or subpentagonal. The inter-ambulacra have four rows of primary and two rows of small secondary tubercles; the under surface is convex, and the mouth-opening small.

2nd. The var. *b*, *subnudum*, has the upper surface remarkably nude, from the absence of granules in the upper part of the miliary zone; the test is higher, and my specimen from the "Chloritic Marl" of Chard has a thicker structure than var. *a*.

3rd. The var. *c*, *Roissyi*, is still higher and much larger than var. *b*; it has a more tuberculous appearance, and from six to eight rows of tubercles in the inter-ambulacra. I have two specimens before me that agree very well with M. Desor's diagnosis of this form, which he considers a good species, or at all events a large variety of *P. subnudum*. After a critical study of all these forms, I can find no good structural character for separating them, and therefore consider them as varieties of *P. variolare*, depending on age or habitat for the differences they exhibit in the size, thickness, and number of tubercles in the inter-ambulacral areas.

Affinities and Differences.—*Pseudodiadema variolare* is one of the most perfect types of a

tetragrammous Diadema with bigeminal pores. It very much resembles *P. Brongniarti*, Agas., from the Grey Chalk, but is distinguished from the latter by having its upper and under surfaces more depressed, the ambulacral areas narrower, their rows of tubercles shorter, and those on the upper surface more rudimentary; the poriferous zones are much wider on the upper fourth, and have the pores more largely bigeminal; the base likewise is more convex, wider, and less contracted than in *P. Brongniarti*.

Locality and Stratigraphical Position.—*P. variolare* is found in the Upper Greensand of Warminster, and the "Chloritic Marl" near Chard; from the latter locality I have specimens that represent the var. *b.*, *subnudum*, and var. *c.*, *Roissyi*. The large specimen was kindly communicated by the Rev. C. W. Bingham, of Binghams Melcombe, near Dorchester; it was collected from the Upper Greensand of that neighbourhood—the precise locality is not recorded.

Foreign Localities.—M. Cotteau has given a wide range to the distribution of this species in France, and records—"Villers-sur-Mer, Cauville, Vaches-Noires, Dives, Saint-Jouin (Calvados); Octeville (Manche); Fécamp, Le Havre, Rouen (Seine-Inférieure); Vimoutiers, Gracé, La Perrière (Orne); Près agny près Vernon (Eure); Berneuil (Oise); Grandpré (Ardennes); La Fauche près le Villard-de-Lans (Isère); Le Mans, La Raglasse, Yvré-l'Évêque (Sarthe); Corzé (Maine et Loire); Touvois (Loire-Inférieure); Angoulême (Charente); île Madame, Saintes (Charente-Inférieure). Assez abondant. Étage Cénomanien, commun surtout dans la zone à *Scaphites æqualis*.—Lillebonne (Seine-Inférieure). Rare. Étage turonien."

In the Hils conglomerate, near Essen, Hanover. Desor.

History.—Figured for the first time by Brongniart in 1822, as *Cidarites variolaris*, in his 'Géognosie Physique des Environs de Paris,' from a specimen collected at Havre in the Upper Greensand.

In the 'Catalogue raisonné des Échinides,' 1846, MM. Agassiz and Desor separated certain varieties of this species from the type which they found in the museums of France, under the names *Diadema subnudum* and *D. Roissyi*; those, however, I have endeavoured to demonstrate are merely varieties of *P. variolare*.

PSEUDODIADEMA BRONGNIARTI, *Agassiz*, 1840. Pl. XX, fig. 2 *a—c*; XXI A, figs. 2 *a—f*, 3, 4; XXI B, figs. 1—3 *a—c*.

TETRAGRAMMA BRONGNIARTI,	*Agassiz.*	Desc. des Échinides fossiles de la Suisse, t. ii, p. 25, pl. xiv, figs. 4—6, 1840.
—	—	*Agassiz* et *Desor.* Catal. rais. des Échinides, Ann. Sc. Nat., 3e sér., t. vi, p. 350, 1846.
—	—	*Bronn.* Index Palæontologicus, p. 1261, 1849.
DIADEMA	—	*D'Orbigny.* Prodrome, t. ii, p. 142, Ét. 19, No. 328, 1850.
—	—	*Renevier.* Mém. Géol. sur la Perte du Rhône, p. 32, 1853.
—	—	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 76, 1854.
PSEUDODIADEMA	—	*Desor.* Synopsis des Échinides fossiles, p. 74, 1856.
DIADEMA	—	*Woodward.* Mem. of the Geol. Surv., Decade V, 1856.
—	—	*Pictet.* Traité de Paléontol., 2e éd., t. iv, p. 244, 1857.
PSEUDODIADEMA	—	*Dujardin* et *Hupé.* Hist. Nat. des Zoophytes, Echinodermes, p. 498, 1862.
—	—	*Cotteau.* Paléontologie Française, Terrain Crétacé, t. vii, p. 456., pl. 1109, 1865.

Test large, subcircular, elevated; sides tumid, depressed at the upper surface, narrow, rounded, and contracted on the under surface; ambulacral areas narrow, with two rows of tubercles, separated by a double series of small granules of unequal sizes; poriferous zones narrow, straight; pores round, in single pairs from the peristome to the ambitus, and bigeminal thence to the disc-opening; inter-ambulacral areas wide, with four rows of primary tubercles, nearly identical in size with those of the ambulacra, and two short rows of very small secondaries near the zones. Mouth-opening small, in a considerable depression; peristome narrow, with feeble and nearly equal-sized entailles.

Dimensions.—A.—Height six tenths of an inch; transverse diameter one inch and a half. B.—Transverse diameter two inches and a half.

Description.—The test of this species exhibits so close a resemblance in many of its anatomical details to that of *Pseudodiadema variolare*, that, were it not for some differences in the size, shape, and development of the shell, and in the structure of the ambulacra, I should hesitate to separate it from that form; after all, these differences may not be specific, but may have arisen from habitat and other physical conditions. A test of each species, with spines attached, for the purpose of comparison, is still with me a desideratum; however, as this Urchin is considered by most authors to be distinct from *P. variolare*, I shall describe the fossils I have figured under the name *P. Brongniarti*, Agas. These

specimens have been compared with typical examples from the Upper Greensand of the Perte du Rhône, and identified as the true forms of *P. Brongniarti*, Agas.

The test is moderately large, sub-circular, and elevated; the sides are tumid, and the upper surface is flat; the base is convex, contracted at the circumference, and having the peristome sunk in a considerable depression (Pl. XXI A, fig. 2 *c*). The ambulacral areas are narrow, and sharply lanceolate; they have two rows of primary tubercles, from sixteen to seventeen in each row, which diminish gradually from the ambitus to the peristome and the disc; they are placed closely together, and have narrow ring-like areolas; the bosses are stout, with sharply crenulated summits, and the mammillons are large and perforated (fig. 2 *c*); a row of granules, of unequal sizes, sometimes mammillated, separates the tubercles at the middle and base of the area, whilst in the upper part branches of fine granules pass off horizontally, forming circlets around the tubercles (fig. 2 *c*). The poriferous zones are narrow; the pores are in single pairs in the middle and infra-marginal region, near the peristome they lie in triple oblique pairs, above the ambitus they fall out of their regular ranks, and at the upper surface are distinctly bigeminal (Pl. XXI A, fig. 2 *b*).

The inter-ambulacral areas are more than twice the width of the ambulacral; they have four rows of primary tubercles nearly identical with those in the ambulacra. The two inner rows are best developed, and extend from the peristome to the disc, whilst the external rows are absent from the three uppermost plates; in the large specimen there must have been sixteen to eighteen tubercles in each internal row (Pl. XX, figs. 2 *a* and *b*); a series of small unequal secondary tubercles ascends from the peristome to above the ambitus, situated between the primary tubercles and the zones (Pl. XXI A, figs. 2 *d*, *e*); they are altogether absent from the upper surface, but constant in the region I have described. The miliary zone is narrow in the infra-marginal region, wider in the middle, and expands at the upper surface; it is filled with four rows of small irregular granules, among which a number of small mammillated tubercles as large as the secondaries are placed (Pl. XXI A, fig. 2 *e*); above the ambitus horizontal branches of granules extend from the median rows, separating the areolas, and forming hexagonal divisions between them (fig. 2 *e*); at the upper fourth of the area the granules disappear from the middle of the zone, and a triangular nude space is exposed, having its base at the disc and its apex at the fifth plate; the circlets of granules are absent from the areolas of these plates.

The upper surface is flat, and the opening for the apical disc large and pentagonal, the angles extending into the inter-ambulacra (fig. 2 *b*.)

The base is convex and contracted at the side; the centre is concave, about one third the width of the shell, and the mouth-opening lies in a considerable depression; the peristome is small, about one third the width of the shell; in a fine test showing the base one and a half inch in diameter; that of the peristome is half an inch (fig. 2 *c*).

Affinities and Differences.—*P. Brongniarti* is distinguished from its congeners by its elevated test, with tumid sides, flat upper surface, and contracted, convex under surface.

THE

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A MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART THIRD.

ON THE DIADEMADÆ.

Pages 113—136; Plates XXII—XXIX, XXIXa, XXIXb.

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The pores are scarcely bigeminal near the summit. The primary tubercles are numerous, nearly uniform in size, and closely set together; the mouth-opening is very small, and lies in a deep depression.

Pseudodiadema variolare has the test in general more depressed, the base wider, and the pores more distinctly bigeminal in the upper fourth of the zones; the base is wider, more convex, and less contracted than in *Ps. Brongniarti*.

Locality and Stratigraphical Position.—*Pseudodiadema Brongniarti* has been collected from the Grey Chalk near Folkestone, from which stratum all the large fine specimens in the British Museum, and those in the Rev. T. Wiltshire's cabinet figured in this Monograph, have been obtained. The Red Chalk of Hunstanton Cliff has yielded a few examples, two of which, from Mr. Rose's and the Rev. T. Wiltshire's collections, are figured in Pl. XXI B. Forms referred to this species have been collected from the Chalk-marl of Maiden Bradley, Dorset, and the Chloritic Marl, Somerset.

Foreign Localities.—Professor Pictet, of Geneva, kindly gave me several type specimens of this Urchin collected from the Gault of the Perte du Rhône (Ain), which so much resemble Professor Agassiz's figures of this species from the same locality that my specimens might have been the originals of the drawings in his 'Échinodermes foss. de la Suisse.' It is found likewise at Escragnolle (Var), Montagne des Fis (Savoie), where it is an abundant fossil in the Étage Albien or the Gault. M. Desor, in addition to these localities, gives Clar and La Presta, as places where this species is abundant.

History.—First figured by M. Al. Brongniart[1] in his 'Description de la Perte du Rhône,' under the name *Cidarites variolaris* (*?*), as a characteristic fossil of the Craie Marneuse; afterwards (1840) it was described and figured by Professor Agassiz in the 'Échinodermes foss. de la Suisse' as *Tetragramma Brongniarti*; afterwards (1856) it was removed by M. Desor into his genus *Pseudodiadema*, where it now remains.

Genus—Pedinopsis, *Cotteau*, 1863.

Test large, round, inflated, sometimes subconical. Poriferous zones wide and straight; the pores bigeminal throughout, forming at the upper surface and ambitus two distinct rows, which become more blended together at the infra-marginal region, and are distinct at the base. Tubercles of both areas small, and nearly the same size; summit of the boss finely crenulated, and the mammillon perforated; the tubercles disposed in regular rows, the number varying in the different species, and always diminishing as they approach the summit; coronal plates long, narrow, and granular; mouth-opening large, peristome moderately developed, circumference slightly incised, apical disc small, subcircular, elements feebly united, absent in the specimens known.

[1] 'Description géologique des Environs de Paris,' troisième édition, 1835, p. 174, pl. M, fig. 9.

This genus was established by M. Cotteau in his memoir[1] on 'Les Échinides des Pyrénées,' and placed near *Pseudodiadema*, with which it has many affinities; the tubercles are crenulated and perforated, and the pores bigeminal throughout, a character which is in part possessed by *Ps. Brongniarti*, *variolare*, &c. It has affinities with *Salmacis* in the number of its pores; in this genus, however, they are arranged in triple oblique pairs, whilst in *Pedinopsis* they are regularly bigeminal throughout.

The original specimen was collected from the Neocomian strata of Aude, where it is rare; another of the same species has been found at Caussols (Var); the one which I now figure was obtained from the Chloritic Marl near Chardstock, Somerset.

PEDINOPSIS WIESTI, *Wright*, nov. sp. Pl. XIV, fig. 1; Pl. XXIX A.

Test moderate in size, circular, inflated at the sides, convex on the upper surface, and flat at the base; ambulacra with two complete marginal rows and two inner incomplete rows of tubercles; inter-ambulacra with six rows of turbercles at the ambitus, the two central of which are complete, and the four lateral incomplete; tubercles nearly all of the same size; pores uniformly bigeminal throughout.

Dimensions.—Height one inch; transverse diameter one inch and seven tenths; mouth-opening six tenths of an inch.

Description.—This rare Urchin forms the type of a new genus, established by my friend M. Cotteau for a similar rare species from the Neocomian of Caussols (Var). The test is of moderate size, circular at the ambitus, inflated at the sides, convex on the upper surface, and flattened at the base. The ambulacral areas are moderately wide, and retain their proportional diameter throughout the area; they have two rows of marginal tubercles of small size, which extend from the peristome to the disc (Pl. XXIX A, fig. 1), and are very regular both in size and arrangement; between the base and upper surface two other rows occupy the centre, so that this area at the ambitus is furnished with four rows of tubercles (Pl. XXIX A, fig. 1 *g*), the two inner rows of which disappear at the lower seventh (fig. 1 *h*) and upper third of the areas (fig. 1 *d*); the tubercles are nearly all of the same size; around the base of the bosses some fine granules are sparsely distributed, which form imperfect circlets around them (Pl. XXIX A, figs. 1 *d*, *e*, *f*, *g*, *h*). None of the marginal rows in the specimen is complete, so that the exact number in each series cannot be ascertained; but as thirty can be counted in one incomplete column, six more may be fairly estimated as wanting (fig. 1 *a*, *b*, *c*).

The poriferous zones are moderately wide, and very uniform in diameter throughout,

[1] "Échinides foss. des Pyrénées," p. 16. Extrait du 'Congrès scientifique de France,' 28e session, tenue à Bordeaux, t. iii, pl. ix, 1863.

expanding, however, near the mouth, where an increased number of holes seem almost completely to encircle the peristome (fig. 1 *h*); throughout the zones the pores are very regularly bigeminal, and are grouped into distinct ranges, the small plates forming these zones being beautifully dovetailed into each other (figs. 1 *d*, *g*, *h*); by this arrangement there are from six to seven pairs of holes opposite each ambulacral plate, which gives $36 \times 6 = 216$ pairs of holes in each zone.

The inter-ambulacral areas are rather more than double the width of the ambulacral; the individual plates are long and narrow, being only a little deeper than those of the latter; two rows of tubercles occupy the centre of the plates, and extend very regularly in size and disposition from the peristome to the disc; on the zonal side of this central row a second row extends from the peristome over three fourths of the area, and between the central row and the median suture there is another row of the same length; in addition to these six rows a few additional tubercles are introduced at the zonal and median sides of the widest ambital region of the area. I have shown this character in figs. 1 *g* and *h*, and the gradual disappearance of the tubercles in the upper part of the area is seen in figs. 1 *a* and *c*, and in its lower part in figs. 1 *b* and *h*; between the tubercles a number of small granules are sparsely distributed over the surface of the plates.

The tubercles in this genus are very uniform in size and structure throughout both areas; the boss rises suddenly from the surface of the plate, without any areolar depression; its summit is very finely crenulated only where it closely embraces the mammillon, which is small, prominent, and perforated at the summit; in the widest part of the areas the granules form imperfect circlets around the tubercles, and an increased ornamentation at the ambitus and base; at the upper surface they become more sparse in the ambulacra (fig. 1 *d*), and are almost entirely absent in the inter-ambulacra (figs. 1 *a*, *c*).

The mouth-opening is nearly circular, about one third the diameter of the test (fig. *b*); the peristome is slightly incised and unequally divided, the ambulacral being much longer than the inter-ambulacral lobes, allowing a wider space for the development of pedal pores around the peristome.

The apical disc is absent, and the upper part of the test is unfortunately broken off, so that no indication of the size or form of the disc remains imprinted on the mould.

Affinities and Differences.—The only two species of this genus at present known are *Pedinopsis Meridanensis*, Cotteau, from the Neocomian of Aude; and *P. Wiesti*, Wright, from the Chloritic Marl near Chardstock. These Urchins resemble each other very much; *P. Meridanensis* (Pl. XXIX A, fig. 2[1]) has a greater number of tubercles; and they are likewise larger and more regularly disposed on the plates; the poriferous zones are wider, and the holes larger than in *P. Wiesti*. The bigeminal character of the zones, the smallness of the tubercles, and the thinness of the shell, are special characters by which this Urchin can be readily distinguished from all other congeners.

[1] Copied from M. Cotteau's 'Paléontologie Française,' pl. 1125, for comparison with the English species.

Locality and Stratigraphical Position.—This specimen was collected by Mr. Wiest, from the Chloritic Marl near Chardstock, Somerset, where it is associated with several species of *Echinidæ* that are characteristic of the Upper Greensand formation.

Echinocyphus, *Cotteau*, 1860.

Glyphocyphus (pars), *Desor*, 1856.
Cyphosoma (pars), *Woodward*, 1857.
Echinocyphus, *Cotteau*, 1860.

Test small, circular, moderately high, more or less inflated on the upper surface, very concave at the base. Poriferous zones straight, and composed of simple pores throughout. Ambulacral and inter-ambulacral tubercles nearly the same size in both areas, bosses crenulated, mammillon not perforated. In many specimens the ambulacra have only one row of tubercles instead of two, their normal number.

The inter-ambulacral plates are marked at the base with more or less well-marked sutural and horizontal impressions. Peristome moderately large, subcircular, sunk in a depression, and provided with slight lobes. Apical disc unknown, opening elongated and subpentagonal, as indicated by the impression.

This genus was established to receive certain species referred by some authors to the genus *Glyphocyphus*, by others to *Cyphosoma*. These species, according to M. Cotteau, are distinguished from *Glyphocyphus* by their imperforate tubercles, their horizontal sutural impressions, and less solid apical disc. Their crenulated and non-perforated tubercles bring them into near relation with certain species of *Cyphosoma*, as *C. Delamarrei* and *C. magnificum*, var. *sulcatum*, which show at the base of their inter-ambulacral plates some traces of sutural impressions; but these feeble depressions, however, cannot be compared with the deep horizontal grooves that characterize *Echinocyphus*, and impart to the few species composing this group the physiognomy of *Glyphocyphus*, with which M. Desor placed them.

Echinocyphus difficilis, *Agass.* Pl. XXII, figs. 1 *a*, *b*, 2 *a*, *b*, *c*, *d*, 4.

Cyphosoma difficile,	*Agass.* Catal. Syst. Ectyp., Mus. Neocom., p. 12, 1840.
— —	*Agassiz* et *Desor.* Catal. rais. des Échinid., Ann. Sc. Nat., 3e série, tom. vi, p. 352, 1846.
— —	*Bronn.* Index Palæontologicus, p. 381, 1848.
Diadema rotulare,	*McCoy.* Mesozoic Radiata, Ann. of Nat. History for December, 1848.
— Maccoyi,	*Forbes.* Catalogue of British Fossils, Morris, 2nd ed., p. 76, 1854.
— rotatum,	*Forbes.* Memoirs of Geological Survey, Decade V, p. 3, 1856.

GLYPHOCYPHUS DIFFICILIS,	*Desor.* Synops. des Échinides foss., p. 104, 1857.
CYPHOSOMA DIFFICILE,	*Woodward* (pars). Mem. of Geol. Survey, Appendix to Decade V, p. 3, 1858.
GLYPHOCYPHUS DIFFICILIS,	*Dujardin* et *Hupé.* Hist. Nat. des Zooph., Échinid., p. 513, 1862.
ECHINOCYPHUS DIFFICILIS,	*Cotteau.* Pal. Française, Ter. Crétacé, t. vii, p. 708, pl. 1174, 1866.
— ROTATUS,	*Cotteau* (pars). Ibid., t. vii, p. 711, pl. 1174-75.

Test small, subcircular, moderately inflated on the upper surface, flattened at the base, concave around the mouth, and rounded at the sides; poriferous zones narrow, straight, and subflexuous at the ambitus; pairs of pores in a single series; ambulacral areas narrow above, enlarged at the ambitus, with two rows of tubercles, one of which is often abortive; inter-ambulacral areas wide, having two rows of tubercles; plates possessing small, strongly radiated areolæ, and divided by deep sutural impressions; apical disc equal to the oral opening, flat, and finely granulated.

Dimensions.—Transverse diameter eight tenths of an inch; height four tenths of an inch.

Description.—This Urchin has long been mistaken for a *Diadema*, and is catalogued in some lists of Upper Greensand fossils as *D. rotatum*. Small specimens, measuring from four to five lines in diameter, are abundant in the Upper Greensand of Warminster, and may readily be distinguished from Diademas by the sutural impressions on their plates, the small radiating ribs on many of the large areolæ, and the irregularity of the two rows of ambulacral tubercles, one of which is often abortive. The larger and taller specimens agree with the published mould of Professor Agassiz's type specimen of *Cyphosoma difficile*, to which this Urchin is now referred.

Almost all the examples I have collected from the Upper Greensand are small and well preserved; the few I have from the Lower Grey Chalk are larger, and show the sculpturing of the plates better. The test is subcircular, or slightly pentagonal, moderately convex on the upper surface, flattened at the base, and rounded at the border. The poriferous zones are narrow, straight above and below, and subundulated at the ambitus. The pores are small, and form a single series of pairs throughout from the mouth to the disc (fig. 2 *d*); the pairs of pores are separated horizontally by small prominent ribs, more or less granular, which correspond to the poriferous plates, and are prolonged to the base of the tubercles. The ambulacral areas are narrow, and provided with two rows of tubercles; in some specimens from the Grey Chalk these rows are regular and the tubercles of equal size, but in many specimens from the Upper Greensand, as in figs. 2 *a*, *b*, *c*, *d*, one row becomes abortive, and the other only is developed; more than half the specimens that have passed through my hands have been thus formed. The inter-ambulacral areas are wide, with two rows of tubercles a little larger than those occupying the ambulacra; in large specimens there are ten or twelve tubercles in each row, the number depending on the age of the individual. Between the ambitus and peristome the areolas are well developed, and surrounded by

circles of large sub-elliptical granules, that are prolonged in a radiated manner towards the base of the mammillon (fig. 2 *d*). The coronal plates at their lower border are marked by a horizontal depression, as if the lower half of the plate had been scooped out (fig. 2 *a*) at the expense of a portion of the granular circle. The boss is prominent, and its summit is marked with feeble crenulations. The mammillon is always large and unperforated. The miliary zone is wide in its upper part, and the surface of the plates is covered with a very fine granulation; at the ambitus it is filled with two or three rows of large granules, which diminish below into a single series, and take a zigzag direction towards the peristome.

The small mouth-opening, about one third the diameter of the test, is lodged in a concave depression (fig. 2 *b*). The peristome is circular, and nearly equally lobed, and the incisions are slight.

The apical disc, which is very rarely preserved (Pl. XXII, fig. 4), equals the oral opening in size, and is flat and finely granulated; the cordate ocular plates are rather large, and perforated close to the ambulacral margin; the large ovarial plates are perforated, and the madreporiform body occupies the right anterior plate; the single posterior plate is wanting.

Affinities and Differences.—This species very much resembles *Cyphosoma rotatum*, Forb., of which it proves to be a variety; the irregularity of the two rows of ambulacral tubercles, one of which is often abortive, is not, according to our observations, a persistent character, and for this reason we regard *E. difficilis* and *E. rotatus* as varieties of one form. M. Cotteau, however, considers them distinct, and takes as a diagnostic character the single row of tubercles in the ambulacral areas, as this difference does not appertain to age, seeing that it is found in small as well as in large specimens. *Echinocyphus difficilis*, Ag., may be confounded with *Glyphocyphus intermedius*, Cott., which has a similar disposition of the ambulacral tubercles, only that they are perforated in *Glyphocyphus* and unperforated in *Echinocyphus*.

Locality and Stratigraphical Position.—I have several specimens which I collected from the hard Grey Lower Chalk near Folkestone, and numerous smaller examples from the Upper Greensand near Warminster; from the latter formation a very large specimen was obtained, now in the cabinet of G. E. Sloper, Esq., Devizes. The late Dr. S. P. Woodward states that it measures nine lines in diameter, and four and a half in height; both rows of ambulacral areas are well developed, and the miliary granules form a prominent framework to the tubercles.

In France, M. Cotteau records this species from the Étage Cénomanien of Vellclaire (Haute-Saône), and Présagny (Eure), where it is rare.

History.—First catalogued as *Diadema rotulare*, Ag., from Durdle Door, Dorset, by Prof. McCoy, in his 'Mesozoic Radiata,' in 1848, and afterwards by Prof. E. Forbes, as *Diadema rotatum*, from the Upper Greensand of Warminster, in the second edition of the 'Catalogue of British Fossils.'

ECHINOCYPHUS MESPILIA, *Woodward.* Pl. XXII, figs. 3 *a, b, c, d.*

CYPHOSOMA MESPILIA, *Woodward.* App. Decade V, Mem. of the Geol. Survey, p. 3, 1856.

Test small, circular, inflated or depressed, convex above and below, with subequal apertures; poriferous zones straight, simple, pairs of pores very oblique; tubercles nearly equal, prominent, imperforate and crenulated; areolæ small, radiated, with elongated miliary granules, sutural impressions slight; inter-ambulacra wide, with two rows of tubercles, seven to eight in each; ambulacra narrow, with seven to eight tubercles, alternate, and irregular.

Dimensions.—Height three lines; transverse diameter five lines.

Description.—This species was discovered by my late friend, Dr. S. P. Woodward, who found it in the Lower Hard White Chalk along with *Cyphosoma simplex*, Forb., and *Salenia granulosa*, Forb. It is a pretty little Urchin, with inflated sides; the test is nearly convex above and below, the poriferous zones are straight and simple, the unigeminal pores are very oblique, the ambulacral areas are narrow, and the tubercles, seven or eight in number, are alternate and irregular (fig. 3), one of the rows being partially abortive. The inter-ambulacral areas are wide, and have two rows of prominent tubercles, seven to eight in each row (fig. 3), which occupy the centre of the plates, and are surrounded by small radiated areolæ, formed by an oblique arrangement of the elongated granules thereon, and imparting an ornamented character to the test. The mouth-opening is more than one third of the diameter of the test, the peristome is nearly equally lobed, and the incisions are wide and deep. The discal opening is larger than the oral in diameter.

Affinities and Differences.—This Urchin very much resembles *E. difficilis;* it has, however, a more inflated test, with stronger radii on the areolæ, and larger oral and discal apertures. Its author considered it "a very distinct species," and called my especial attention to it. A careful comparison of the accurate figures of both species drawn on Pl. XXII will enable the student to appreciate the affinities and differences between them better than any description, however elaborate.

Locality and Stratigraphical Position.—*E. mespilia* has been collected only from the Lower Chalk, in the hard beds of which it has been found, associated with *Cyphosoma simplex* and *Salenia granulosa.* The only specimens I have seen are in the British Museum.

Genus—GLYPHOCYPHUS, *Haime*, 1853.

ARBACIA (pars), *Agassiz*, 1836.
ECHINOPSIS (pars), *Agassiz*, 1846.
HEMIDIADEMA, *Agassiz*, 1846.
TEMNOPLEURA (pars), *Sorignet*, 1850.
GLYPHOCYPHUS, *Jules Haime*, 1853.
— *Desor*, 1856.
— *Cotteau*, 1859.

The Urchins forming this group have a small circular test, more or less inflated above and concave below. The poriferous zones are straight, depressed, and composed of unigeminal pores throughout. The primary tubercles of both areas are nearly of the same size. The boss, with its crenulated summit, is surrounded by a distinct areola, and surmounted by a small mammillon minutely perforated at the vertex. The ambulacral and inter-ambulacral plates are marked with sutural depressions, which are wider and deeper on the plates of the latter areas; the surface is covered with fine, close-set homogeneous granules, nearly uniform in size over the whole test (Pl. XXIX B, figs. 1 and 2). The apical disc is a small annular structure, solidly united to the test, and forming a narrow, slightly elongated, oblong ring, composed of five ovarial and five ocular plates, articulated alternately together on the same line around the vent aperture or periprocte (fig. 2 *b*). The ovarial plates are the largest; they have a triangular shape, with tubercles external to the annulus, and a large hole at the apex; the right antero-lateral plate is the largest, and supports the madreporiform body. The rhomboidal ocular plates are wedged in alternately on the same line with the ovarials; and the portion external to the annulus is covered with numerous granules. Mouth-opening is small, subcircular, and sunk in a slight depression; peristome decagonal, divided into lobes by feeble incisions.

The genus *Glyphocyphus* forms among the DIADEMADÆ with crenulated and perforated tubercles a very small group, in which the ambulacral and inter-ambulacral plates are marked with angular impressions, and their surface covered with prominent close-set granulations. The solidity of the apical disc, and its firm articulation to the coronal plates, with the regularity as regards size and arrangement of the tubercles in both areas, form an assemblage of characters which readily distinguish the small Urchins of this group from their congeners. A considerable difference of opinion has prevailed amongst Echinologists regarding the true characters of the forms now comprised in this genus, arising, doubtless, from the smallness of the individuals themselves, the imperfect preservation of most of the specimens, and the destruction of many of the essential structures that distinguish them. M. Cotteau, however, had lately at his disposal a fine series of

beautiful and perfect specimens of *Glyphocyphus radiatus*, collected by the late M. Triger from the Terrain Crétacé of the department of the Sarthe, and from the study of these M. Cotteau has been enabled to clear up doubts that had previously existed regarding the structure of many of the species. This genus is nearly allied to *Echinocyphus*, which presents a similar facies of lateral impressions on the ambulacral and inter-ambulacral plates, but is distinguished from it by having the mammillons of the tubercles perforated, whereas in *Echinocyphus* they are imperforate. The apical disc is, likewise, solidly united to the coronal plates in *Glyphocyphus*, but slenderly so in *Echinocyphus*. M. Agassiz proposed the genus *Hemidiadema* for Urchins differing from the Diademas in one character, that the ambulacral areas possessed only a single row of tubercles, and cited as the type of this group *Hemidiadema rugosum*, Agass., from the Upper Greensand (Étage Cénomanien) of Grandpré, Ardennes, a small species having the ambulacral tubercles as large and even larger than the inter-ambulacrals; this Urchin, it now appears, is a true *Glyphocyphus*, with a single row of tubercles in its ambulacral areas—a character which is only specific, and not generic, as far as we at present know.

The genus *Echinopsis*, Agass., in which certain species of *Glyphocyphus* have been placed, consists, according to its author, of "small, subconical, inflated Urchins, with the ambulacra nearly as large as the inter-ambulacra, and both ornamented with tubercles perforated but not crenulated. Mouth small, with feeble incisions, differing from the Diademas by the absence of crenulations on the tubercles." To this genus was referred *Echinopsis contexta*, Ag., *E. latipora*, Ag., *E. depressa*, Ag., all of which are forms of *Glyphocyphus radiatus* and *Glypticus Koninckii*, Forb. *Echinopsis pusilla*, Roem., and *Temnopleurus pulchellus*, Coquand, must now likewise be added to the list.

GLYPHOCYPHUS RADIATUS, *Hœninghaus*. Pl. XXIX B, figs. 1, 2, *a*, *b*, *c*, *d*, *e*.

ECHINUS RADIATUS,	*Hœninghaus* in *Goldfuss*. Petref. Germaniæ, p. 124, tab. xl, fig. 13, 1826.
— —	*Agassiz*. Prod., Mém. Soc. Nat. des Sc. de Neufchâtel, t. i, p. 196, 1836.
— —	*Desmoulins*. Études sur les Échinides, p. 292, No. 55, 1837.
ECHINOPSIS LATIPORA,	*Agassiz*. Catal. Syst. Ectyp. foss., Mus. Neoc., p 9, 1840.
— CONTEXTA,	*Agassiz*. Ibid.
— DEPRESSA,	*Agassiz*. Ibid.
ECHINUS RADIATUS,	*Dujardin*. In Lamarck's Anim. sans Vert., 2e éd., t. iii, p. 371, 1840.
ARBACIA RADIATA,	*Roemer*. Norddeutschen Kreidegebirges, p. 30, 1840.
ECHINOPSIS PUSILLA,	*Roemer*. Ibid., pl. vi, fig. 10, 1840.
CYPHOSOMA RADIATUM,	*Agassiz* et *Desor*. Ann. Sc. Nat., 3e série, t. vi, p. 352. Cat. rais. des Échinides, 1846.

ECHINOPSIS LATIPORA, *Agassiz* et *Desor*. Ibid., p. 351, 1846.
— CONTEXTA, *Agassiz* et *Desor*. Ibid.
— DEPRESSA, *Agassiz* et *Desor*. Ibid.
— CONTEXTA, *Bronn*. Index Palæontologicus, p. 447, 1848.
— DEPRESSA, *Bronn*. Ibid.
— LATIPORA, *Bronn*. Ibid.
— PUSILLA, *Bronn*. Ibid.
ARBACIA RADIATA, *Bronn*. Ibid., p. 91, 1848.
TEMNOPLEURUS PULCHELLUS, *Sorignet*. Ours. fossiles du Dép. de l'Eure, p. 31, 1850.
GLYPTICUS KONINCKII, *Forbes*. In Dixon's Geology of Sussex, p. 340, tab. xxv, fig. 30, 1850.
ECHINOPSIS PUSILLA, *Forbes*. In Dixon, ibid., tab. xxv, fig. 31, 1850.
— — *Giebel*. Deutschlands Petrefacten, p. 320, 1852.
GLYPHOCYPHUS PULCHELLUS, *d'Archiac* et *Jules Haime*. Descript. Nummilites de l'Inde, p. 202, 1854.
ECHINOPSIS PUSILLA, *Morris*. Catal. of Brit. Fossils, 2nd. ed., p. 78, 1854.
— LATIPORA, *Pictet*. Traité de Paléontol., 2e éd., p. 242, 1846.
— CONTEXTA, *Pictet*. Ibid.
— DEPRESSA, *Pictet*. Ibid.
— PUSILLA, *Pictet*. Ibid.
CYPHOSOMA RADIATUM, *Pictet*. Ibid.
GLYPHOCYPHUS RADIATUS, *Desor*. Synopsis des Échinides fossiles, p. 103, tab. xvii, figs. 1—3, 1856.
— — *Cotteau* et *Triger*. Échinides du dép. de la Sarthe, p. 185, pl. xxviii, figs. 7—12, 1859.
— — *Dujardin* et *Hupé*. Hist. nat. des Échinod., p. 513, 1862.
TEMNOPLEURUS PULCHELLUS, *Coquand*. Géol. et Pal. de la prov. de Constantine, p. 294, 1863.
GLYPHOCYPHUS RADIATUS, *Cotteau*. Paléont. Franç., Ter. Crétacé, t. vii, p. 535, pl. 1127, 1128, 1863.

Test small, circular, inflated, subglobular, rounded at the border and concave at the base; ambulacra very narrow, with two rows of tubercles, alternate, irregular. Poriferous zones narrow, straight; simple pores in single oblique pairs. Inter-ambulacra with two rows of small tubercles, areolæ radiated, plates grooved at the lower border; apical disc solid, forming a narrow, elongated, subpentagonal ring, having the genital and ocular plates almost of equal length; oculars finely granulated; vent large, oblong.

Dimensions.—Height five twentieths of an inch; transverse diameter eight twentieths of an inch.

Description.—This small Urchin has been a great puzzle to Palæontologists, as proved by the long list of synonyms given above. The test is circular, inflated, and subglobular; rounded at the sides, and concave towards the base (figs. 1 *a*, *b*). The ambulacral areas (fig. 2 *e*), about half the width of the inter-ambulacral, have two rows of small tubercles, which form an alternate series on each side of the area; they are largest at the ambitus, smaller

at the base and upper surface; they are feebly developed throughout, and finely perforated at the summit; the areolæ are regularly spaced out and placed on the border of the poriferous zones, which are straight, slightly depressed, and formed of small round pores, disposed in single oblique pairs throughout, from the peristome to the disc; the pairs of pores are separated from each other by a horizontal granular ridge of the test, which is more or less apparent in different specimens; in some examples one of the rows of tubercles becomes abortive; the surface of the area is filled in with numerous small granules, and the ambulacral plates are slightly marked with impressions on the line of the median suture. The inter-ambulacral areas, fig. 2 *d*, are double the width of the ambulacral, and provided with two rows of tubercles, similar in structure to, but larger in size than, those of the ambulacra; the areolæ occupy the centre of the plates, and are surrounded with a close-set granulation; two of the granules, elongated in a vertical direction, unite the contiguous areolæ, which imparts a moniliform character to well-preserved tests of this pretty little Urchin; the plates are marked with impressions more or less deep at the inner and outer angles, and on each side of the vertical filament at the lower part of each plate (fig. 1 *c*, fig. 2 *c*).

The mouth-opening is small, situated in a slight depression, and the peristome is delicately incised into ten unequal lobes (fig. 2 *a*).

The vent is large, sub-elliptical in shape, and contracted behind; the apical disc forms a narrow, elongated, subpentagonal ring, somewhat peculiar in its structure, for instead of the small ocular plates being wedged in between the larger genitals, they are arranged alternately with them on the same line, and form a strong ring around the elliptical vent; the genital plates are a little larger than the oculars, and have two small tubercles on their surface; the oculars are covered with a fine granulation, and the madreporiform tubercle is conspicuous by its spongy surface (fig. 2 *b*).

This Urchin varies much in size; the specimens figured by Goldfuss, Desor, and Dixon, with those I possess, are all small. M. Cotteau has given elaborate details of a larger specimen found in the Department of the Sarthe, in which the characters of the test are admirably exhibited; they are beautifully figured, both in his fine plates on the Échinides of the Sarthe, and likewise in those in the 'Palæontologie Française,' some of which I have copied in Pl. XXIX B, as none of my specimens have the characters so well preserved as in the perfect fossil test figured by my friend.

Affinities and Differences.—Glyphocyphus radiatus is so rare an Urchin in the English Chalk that it is not likely to be mistaken for any other. It is smaller and more globular than *Echinocyphus difficilis*, which it most resembles, and has the tubercles perforated, the miliary zone wider and more granular, the disc smaller and more solidly united to the coronal places than in any *Echinocyphi*.

From a careful examination of the ample materials at his disposition, M. Cotteau concludes that the large examples forming the type of the species represent *Echinopsis contexta*, Ag., and exhibit natural impressions either deep and angular or linear and attenuated. Some specimens, less inflated, and possessing a stronger development of the

vertical filament form *E. latipora*, Ag., and depressed examples with the median impression almost absent are *E. depressa*, Ag. A careful study of the original types has, however, convinced my learned friend that they are all varieties of one form, and not distinct species.

Locality and Stratigraphical Position.—This species is found very rarely in the hard beds of the Lower Chalk near Lewes, in Sussex, and in the Grey Chalk near Folkestone. From this stratum my best specimen was collected by Captain Cockburn, R.A., to whose kindness and liberality I am indebted for the example.

The Foreign Localities given by M. Cotteau are Villers-sur-Mer, Bruneval, Saint-Jouin, Vaches-Noires, Dives (Calvados); Fécamp, le Havre, Rouen (Seine-Inférieure): Gacé, La Perrière (Orne); Nogent-le-Bernard (Sarthe); Saint-Fargeau (Yonne); la Bedoule, Cassis (Bouches-du-Rhône). In all these localities it is very rare, and occurs in the Etage Cénomanien, in the zone of *Scaphites æqualis*, which is the equivalent of the English Lower Grey Chalk.

History.—This species was found in the Lower Chalk of Essen and Gehrden, Westphalia, and was first figured and described by Goldfuss in his 'Petrefacta Germaniæ.' Since that time it has passed through a series of changes which are most correctly read in the long list of synonyms introductory to this article, and to which I commend the reader's especial attention.

Genus—Echinothuria,[1] *Woodward*, 1863.

"*Test* globular?, diameter of compressed specimen four inches, thickness half an inch, lantern projecting half an inch; composed of ten segments or double series of imbricating plates, ornamented with obscure miliary granules and small spine-bearing tubercles, a few larger than the rest; *inter-ambulacral* plates narrow, slightly curved, with the convex edge upwards and overlapping; the alternate plates bearing one large extero-lateral tubercle, perforated, and surrounded by a raised ring and smooth areola; largest plates measuring six lines in length, the smallest three lines or less (the longest in second specimen equalling seven lines); *ambulacral* plates seven lines long, equalling the breadth of the exposed portion of eight plates, similar to the former, but curving and imbricating downwards towards the dental orifice, and having two small plates, each perforated by a pair of pores, intercalated in a notch of the middle of the lower margin; a third pair of pores perforating the plate itself a little external to the centre; primary tubercles few, irregularly distributed.

[1] "Etymologists need not trouble themselves about the derivation of this name; it is intended merely to express the dilemma in the writer's mind, arising from imperfect knowledge, but which he believes to have no foundation in nature."—'Geologist,' vol. vi, p. 330.

"*Spines* of three kinds; those adhering to the plates minute and striated; fragments of larger spines (not certainly belonging to the species) striated, annulated, and furnished with a prominent collar to the articular end (fig. 4); the third kind minute, clavate, and truncate, articulated to a slender stalk" (fig. 5).

ECHINOTHURIA FLORIS, *Woodward*.[1]—Pl. XXIX B, figs. 3—5.

ECHINOTHURIA FLORIS, *Woodward*. 'Geologist,' vol. vi, pp. 327—330, 1863.

"The fossils represented" in Pl. XXIX B "are probably only fragments of the original structure, and possibly only the smaller and less essential portions of the whole. Nevertheless, I have determined to publish some account of them, although at the risk of committing an extravagant error, as a last resort towards obtaining more complete examples or suggestions for their more correct interpretation.

"Both specimens have been presented to the British Museum; one by J. Wickham Flower, Esq., of Park Hill, Croydon, the other by the Rev. Norman Glass, of London.

"The first example was obtained, at least sixteen years ago, from the Upper Chalk of Higham, near Rochester, and was submitted to Professor E. Forbes, in whose custody it remained for several years. It was originally shown to me in connection with the anomalous Cirripede *Loricula*, then newly discovered by Mr. Wetherell. The resemblance between them is certainly curious; but there is no real relationship. Mr. Flower's fossil exhibits distinct traces of the crystalline structure peculiar to petrified Echinodermata, and the pairs of pores in the ambulacral plates are equally characteristic of the Echinidæ. Mr. Darwin also has examined this fossil and rejected it from his province of inquiry.

"Professor Forbes could not make up his mind to describe the specimen, and ultimately it was returned to Mr. Flower, with whom it remained until the publication of a note on the genus *Proto-echinus*, by Major Thomas Austin, in the 'Geologist' for 1860 (vol. iii, p. 446), when it was entrusted to me for the purpose of considering whether it had any special affinity with this new type, and for description in the same journal.

"The *Proto-echinus* was obtained from the Carboniferous Limestone of Hook Head, Wexford, and is but a fragment of a single ambulacrum, consisting of three series of plates at the wider end and two at the other extremity, with apparently a single terminal

[1] 'On *Echinothuria floris*, a new and anomalous Echinoderm from the Chalk of Kent.' By S. P. Woodward, F.G.S. I have printed this paper from the 'Geologist' entire (altering the references to figures), as a contribution to British Echinology by my late esteemed friend. Dr. Woodward took so warm an interest in my work, and afforded me such valuable assistance, by the loan of specimens for figuring, that it affords me very great pleasure to acknowledge here his uniform kindness, and connect his name with a Monograph to which he contributed important aid.

plate. Each plate is perforated by a pair of pores. It differs from *Echinothuria* in every particular.

"The question presented to me by Mr. Flower's fossil was, whether to consider it part of the envelope of a new kind of *Holothuria*, or whether it might be no more than a fragment of the oral disc of some great unknown *Echinus*. Portions of the imbricating scaly armour of a *Psolus* had been met with when examining the fossils of the Boulder Clay collected by Mr. J. Richmond, of Rothsay; but in *Psolus*, while the greater part of the body is clothed with fish-like scales, the ambulacra are only developed on one side, forming a creeping disc, the scales of which are small and not imbricated. On the other hand, the peristome of the largest known Echinite from the Chalk is less than an inch in diameter; and the largest recent Sea-urchin in the Museum has an oral disc not more than two inches wide, whereas the fossil is a segment of a disc which must have been at least four inches across. This objection, on the score of size, was, however, less felt, because the Cyphosomas and Diademas of the Chalk have larger oral and apical orifices than any other Urchins, and the character of their apical disc was unknown, being only preserved in a few minute specimens of *C. difficile*, from Chute Farm. Moreover, there were indications in the Upper Chalk of a great *Diadema*, of which nothing more had been obtained than scattered plates and fragments of spines. This species is referred to in Decade V of the 'Geological Survey' (Article "Diadema," Section C, spines tubular, annulated). Mr. Wetherell obtained a mass of Chalk containing above one hundred fragments of spines, which are hollow, striated and annulated, as in the recent *D. calamaria*. From the plates mingled with the spines we ascertained that the ambulacral pores presented the usual characters, being arranged in single file, and a little crowded near the peristome; but many of the plates presented only their smooth inner surfaces. A smaller mass of Chalk, in Mr. Wiltshire's cabinet, contains similar plates and spines, mingled with a few true scales and minute truncated spines like those of *Echinothuria*. The Diadema spines were erroneously referred by Professor E. Forbes to the genus *Micraster* (Decade III, pl. 10, fig. 15; bad, for they are not spiral). They are also figured by Dixon, in his 'Geology of Sussex,' and described by Forbes as "spines of a Cidaris." Diademas possessing spines of this character are known to occur in the Upper Cretaceous strata of France; and Dr. Wright has lately obtained a small specimen from the Chloritic Marls of Dorsetshire. In these the apical disc is quite small.

"A more serious difficulty, in comparing Mr. Flower's fossil with the oral disc of any Echinite, was presented by the arrangement of the plates; in the recent Echinidæ . . . . . they are all directed towards the dental orifice, but here the alternate series take opposite 'dips,' the ambulacral plates overlapping one way and the others in a contrary direction.

"Last year, while I was still hesitating about the publication of Mr. Flower's fossil, a second specimen was obtained from Charlton, in Kent, by the Rev. N. Glass, who has cleared it from the matrix with great skill and patience. . . . . At first sight this specimen would seem to solve the problem, by supplying the peristome and lantern of the same

great *Cyphosoma* or *Diadema*, of which Mr. Flower's specimen might be the apex or periproct. But a closer examination confirms the objections already stated, and gives increasing probability to the other conjecture (if, indeed, it does not compel us to adopt it), however difficult it may be to realise the notion of an Echinite having no proper 'test,' and clothed entirely with imbricating scales like those of the peristome of *Cidaris*.

"In Mr. Flower's specimen the imperforate plates imbricate towards the centre (or apex), where the smaller ends of the several series converge. In Mr. Glass's specimen they slope away from the centre (or mouth), that is, also towards the apex. The perforated or ambulacral plates, which overlap one another outwardly (*i. e.* downwards) in specimen, fig. 3 *a*, are seen sloping towards the dental cone and reclining upon it. The portion of an ambulacrum, fig. 5 *a*, consists of four plates, diminishing in size from *c* to *a*, in a line not accurately directed towards the centre. This portion exhibits the *interior* surface of the plates, known by their curved surfaces, destitute of ornamental granules; it is not, however, the oral end of one of the segments turned over, a thing scarcely possible to happen, for in that case the dip of the plates would be reversed; but it must be the opposite (or apical) extremity of a series folded back upon its origin, and exposed to view by the damage which the surface of the specimen has sustained. From this circumstance it seems probable that the whole fossil, when complete, was not elongated, nor even spherical, but somewhat depressed in a vertical direction, though doubtless admitting of a moderate amount of flexure. At the last hour, after making the drawing, I ventured to clear away the chalk from the side of Mr. Glass's fossil, near where an ambulacral segment is seen to curve as if it might be continued round to the other surface. This attempt was successful, for the ambulacrum and also the adjacent inter-ambulacral segment were found continuous, though crowded and displaced at the turning, falling again into regular order, and diminishing in size, though not so nearly complete as in Mr. Flower's example.

"After this apparently conclusive demonstration, it appears desirable to give a name to the fossil, and to attempt a short description, although its rank and affinities are to us still matter of conjecture. At present it is one of those anomalous organizations which Milne-Edwards compares to solitary stars, belonging to no constellation in particular. The disciples of Von Baer may regard it as a 'generalised form' of Echinoderm, coming, however, rather late in the geological day. The publication of it should be acceptable to those who base their hopes on the 'imperfection of the geological record,' as it seems to indicate the former existence of a family or tribe of creatures whose full history must ever remain unknown."

Locality and Stratigraphical Position.—Collected from the Upper Chalk of Higham, near Rochester. The fine specimens in the Rev. T. Wiltshire's cabinet were obtained from the Upper Chalk at Gravesend and Charlton.

Genus—Cyphosoma, *Agassiz*, 1840.

Cyphosoma, *Agassiz*, 1840.
Phymosoma, *Haime*, 1853.
— *Desor*, 1858.
Cyphosoma, *Cotteau*, 1863.

Test moderate in size, circular or subpentagonal, slightly inflated at the sides. Poriferous zones well developed and undulated, composed of simple pores that in general are unigeminal throughout, and sometimes are bigeminal on the upper surface, and crowded a little together around the peristome. The poriferous plates are unequal and irregular in their mode of arrangement. The primary tubercles are nearly equal in size in both areas, the areolæ are well developed, and sometimes marked with radiated striations; the bosses are prominent, and have their summits sharply crenulated; the mammillon is large, prominent, and imperforate, and the general facies of the test shows a regular, and uniform development of all its several elements. The mouth-opening is large, the peristome slightly incised, and the oral lobes nearly equal. The discal opening is large and pentagonal, one angle of which extended far into the single inter-ambulacrum; the elements of the disc were feebly united, as they are absent in all the specimens that have hitherto been collected.

The spines are long, solid, subcylindrical, aciculate, or spatuliform; sometimes they are straight and lanceolate, or bent, ramiform, or spoon-shaped; all these varieties are figured in Pls. XXIV and XXVI. The stem is smooth and marked with fine longitudinal striæ, the milled ring is prominent, the head distinct, and the rim of the acetabulum crenulated.

The genus *Cyphosoma* is distinguished from all others by its prominent tubercles with crenulated bosses, and imperforate mammillons; in the structure of these it resembles *Echinocyphus* and *Temnopleurus*, but is readily distinguished from these by the absence of the angular and sutural impressions which impart so marked a character to their tests.

M. Desor has separated into the genus *Coptosoma* all those *Cyphosomata* from the Nummulitic formation (Tertiary) with much undulated poriferous zones, tubercles with very large mammillons, and having the plate-sutures of the areas deeply incised; thus leaving the typical *Cyphosomata* as true Cretaceous fossils, which first appear in the Neocomian beds, and attain their maximum development in the upper stage of the White Chalk.

The Cretaceous rocks of France are very rich in species of *Cyphosoma*, of which a very small proportion have hitherto been found in the British islands.

A.—*Species from the Lower Chalk.*

CYPHOSOMA GRANULOSUM, *Goldfuss*, sp., 1826. Pl. XXIII, figs. 2 *a*, *b*, *c*, *d*.

CIDARITES GRANULOSUS,	*Goldfuss.* Petrefact. Germaniæ, pl. xl, fig. 7, p. 122, 1826.
DIADEMA GRANULOSUM,	*Agassiz.* Prod., Mém. Soc. des Sc. Nat. de Neufchatel, t. i, p. 189, 1836.
ECHINUS MILLERI,	*Desmoulins* (pars). Études sur les Échinides, p. 294, No. 68, 1837.
ECHINUS GRANULOSUS,	*Dujardin.* In Lamarck's Anim. sans Vertébres, 2e éd., t. iii, p. 372, 1840.
CIDARITES GRANULOSUM,	*Geinitz.* Charakt. der Schict. und Petref., p. 90, 1842.
DIADEMA —	*Morris* (pars). Catalogue of British Fossils, p. 51, 1843.
CYPHOSOMA —	*Reuss.* Verstein. der Böhm. Kreideform., p. 58, 1846.
— MILLERI,	*Agassiz* et *Desor* (pars). Catalogue rais. des Échinid., p. 351, 1848.
— —	*Bronn.* Index Palæontologicus, p. 381, 1848.
— —	*D'Orbigny.* Prod. Pal. strat., t. ii, p. 273, Ét. 22, 1850.
— —	*Bronn.* Lethæa Geognost., Kreide-gebirges, pl. xxix, p. 186, 1851.
— KÖNIGI,	*Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 75, 1854.
PHYMOSOMA GRANULOSUM,	*Desor.* Synops. des Échinid. foss., p. 87, 1856.
CYPHOSOMA —	*Woodward.* Mem. Geol. Surv., Dec. V, p. 1, 1857.
PHYMOSOMA —	*Hupé.* Hist. Nat. Échinod., p. 508, 1862.
CYPHOSOMA —	*Cotteau.* Pal. Française, Ter. Crétacé, t. vii, p. 685, pl. 1169, 1865.

Test large, circular, depressed, convex on the upper surface, inflated at the sides, and flattened below; poriferous zones wide and straight in the upper third, narrow and undulated at the ambitus and base; pores largely bigeminal in the wide upper third, and unigeminal in the rest of the zones; ambulacra narrow above, wide below, with two rows of large tubercles, twelve in each; inter-ambulacra with two rows of primary tubercles in the middle of the area, secondary tubercles wanting in young specimens, and only slightly developed in the largest tests; miliary zone wide, depressed, and naked above, narrow and granular below; mouth-opening small and circular; peristome with shallow entailles; discal opening large, and widely pentagonal.

Dimensions.—Height eight tenths of an inch; transverse diameter one inch and eight tenths.

Description.—This Urchin resembles *C. Königi* in so many points of structure, the absence or rudimentary condition of the secondary tubercles excepted, that it may probably be only a variety of that species. It has, however, been treated by different sys-

tematic authors as specifically distinct; and in deference to their opinion, rather than in accordance with my own convictions, I have devoted this article to its description.

The test large and circular, inflated at the ambitus, convex above, and flat below (Pl. XXIII, figs. 2 *a*, *b*, *c*).

The ambulacral areas are enlarged at the ambitus, moderately wide at the base, and very narrow in the upper part; by reason of the increased development of the poriferous zones in this region, from the ambitus to the peristome, the tubercles are as large as those in the inter-ambulacra, but in the upper third of the area they diminish rapidly in size, and on the four or five coronal plates they are quite rudimentary (Pl. XXIII, fig. 2 *a*). The pores are arranged in oblique pairs, and are bigeminal from the ambitus to the summit (Pl. XXIII, fig. 2 *c*, *d*), and unigeminal from the ambitus to the peristome, the zones forming a series of crescents around the areolæ of the ambulacral tubercles.

The inter-ambulacral areas have two rows of primary tubercles, twelve to thirteen in each row, which vary gradually in size from the ambitus to both apertures; they are surrounded by well-developed areolæ, confluent at the upper and lower borders, and surrounded by granules at the sides. The secondary tubercles are irregular, very small, and limited to the under surface (fig. 2 *b*). On one or two plates above the ambitus there are only one or two solitary tubercles, which are, however, inconstant in different specimens (fig. 2 *d*). The miliary zone is narrow and granular at the ambitus, and wide, depressed, and naked on the upper surface; the granules are unequal, of different sizes, and placed in semicircular groups around the lateral parts of the areolæ. Many of the granules are large and mammillated, and are nearly as large as the row of secondary tubercles, the small granules being compactly fitted in between them. The coronal plates are marked by slight sutural impressions, which become more apparent in consequence of the nudity of the depressed upper surface of the areas.

The discal opening is very large, pentagonal, and angular; and the single posterior ovarial plate is projected far into the area (fig. 2 *a*). The mouth-opening is moderate in diameter (fig. 2 *b*); the peristome is circular, and divided into ten unequal lobes by slight incisions with reflexed borders.

Affinities and Differences.—This species differs from the typical forms of *Cyphosoma Königi* in the absence of a regular series of secondary tubercles above the ambitus; but in the general character of the test and in most of its details it has close affinities with that species. Whether the spines of this Urchin exhibit any difference from those attached to the typical form of *C. Königi* (Pl. XXIV, fig. 1) remains to be determined by those who may be fortunate enough to discover a specimen with the spines adherent to the test.

Locality and Stratigraphical Position.—This Urchin is found in the Lower Chalk of Kent and Sussex. The specimen figured in Pl. XXIII, belonging to the British Museum, was collected near Lewes.

Foreign Localities.—Houguemarre (Eure), Orglande (Manche), from the Étage Sénonien, where it is rare (M. Cotteau); the type of Goldfuss's figure was collected from the Chalk of Westphalia.

B.—*Species from the Upper Chalk.*

CYPHOSOMA KÖNIGI, *Mantell.* Pl. XXIII, figs. 1, 2; Pl. XXIV, figs. 1—7; Pl. XXV, fig. 3; Pl. XXVI, fig. 1.

ECHINITE.	*Parkinson.* Organic Remains, vol. iii, pl. i, fig. 10, 1811.
CIDARIS KÖNIGI,	*Mantell.* Geology of Sussex, p. 180, 1822.
ECHINUS MILLERI,	*Desmarest.* Oursins fossiles, Dict. Sc. Nat., t. xxxvii, p. 101, 1825.
CIDARITES VARIOLARIS,	*Goldfuss.* Petref. Germaniæ, p. 123, pl. xl, figs. 9 *a*, *b*, 1826.
ECHINUS KÖNIGI,	*Fleming.* British Animals, p. 479, 1828.
CIDARITES KÖNIGI,	*Brongniart.* Tableau des Terrains, p. 405, 1829.
ECHINUS KÖNIGI,	*Woodward.* Synopt. Tab. of Brit. Organ. Rem., p. 6,1830.
— —	*De Blainville.* Zoophytes, Dic. Sc. Nat., t. lx, p. 210, 1830.
— MILLERI,	*De Blainville.* Ibid.
— —	*Agassiz.* Prod., Mém. Soc. Sc. Nat. de Neufchatel, t. i, p. 190, 1836.
— —	*Desmoulins.* Études sur les Échinides foss., p. 294, No. 68, 1837.
DIADEMA KÖNIGI,	*Desmoulins* (pars). Ibid., p. 312, No. 10, 1837.
CYPHOSOMA MILLERI,	*Agassiz.* Catal. Syst. Ectyp., p. 11, 1840.
DIADEMA GRANULOSUM,	*Morris.* Catalogue of British Fossils, p. 51, 1843.
CYPHOSOMA MILLERI,	*Agassiz* et *Desor* (pars). Catal. rais. des Échinides, p. 351, 1846.
— ORNATISSIMUM,	*Agassiz* et *Desor.* Ibid., p. 352, 1846.
— MILLERI,	*Graves.* Essai Topogr. Géognost. Dép. l'Oise, p. 688, 1847.
— MAGNIFICUM,	*Graves.* Ibid.
DIADEMA KÖNIGI,	*Bronn.* Index Palæontologicus, p. 418, 1848.
CYPHOSOMA MILLERI,	*Bronn* (pars). Ibid., p. 381, 1848.
— —	*D'Orbigny.* Prodrom. de Pal. strat., t. ii, p. 273, 1850.
— ORNATISSIMUM,	*D'Orbigny.* Ibid., t. ii, p. 273, 1850.
— MILLERI,	*Forbes.* In Dixon's Geol. of Sussex, pl. xxv, figs. 17, 26, 27, 1850.
— VARIOLARIS,	*Forbes.* Ibid., pl. xxv, fig. 29, 1850.
ECHINUS KÖNIGI,	*D'Archiac.* Hist. des Progr. de la Géol., t. iv, p. 20, 1851.
CYPHOSOMA KÖNIGI,	*Forbes.* Morris, British Fossils, 2nd ed., p. 75, 1851.
— ORNATISSIMUM,	*Forbes.* Ibid.
PHYMOSOMA KÖNIGII,	*Desor.* Synopsis des Échinides fossiles, p. 86, 1856.
CYPHOSOMA KÖNIGI,	*Pictet.* Traité de Paléontologie, 2e éd., t. iii, p. 243, 1857.
— ORNATISSIMUM,	*Pictet.* Ibid.

Cyphosoma Königi,		*Woodward.* Mem. Geol. Surv., Decade V, Appendix, 1857.
Phymosoma	—	*Dujardin* et *Hupé.* Hist. Nat. des Zooph., p. 508, 1862.
Cyphosoma	—	*Woodward.* "On König's Sea-urchin," Geologist, vol. v, p. 41, 1862.
—	—	*Cotteau.* Paléontologie Française, t. vii, p. 678, pl. 1167, 1168, 1863.

Test large, subcircular, depressed, convex on the upper surface, inflated at the sides, almost flat on the under surface; poriferous zones wide and straight in the upper third, narrow and undulated at the ambitus and base; pores bigeminal in the upper third, unigeminal in the lower two thirds of the zone; ambulacra narrow above, wider below, with two rows of large tubercles, twelve in each; inter-ambulacra with two regular rows of primary tubercles in the middle, and two rows of secondary tubercles, irregular in size and distribution, on the zonal sides of the area; miliary zone wide, naked, and depressed above, narrow and granular below; mouth-opening small, peristome circular, lobes nearly equal; discal opening large, pentagonal; spines long, subcylindrical; upper third of the stem aciculate, spatulate, straight or bent; lower third sculptured with fine longitudinal lines.

Dimensions.—Height seven tenths of an inch; transverse diameter two inches.

Description.—This is one of the largest, most beautiful, and typical of our British Cyphosoma; it was well figured by Parkinson, 1811, in his 'Organic Remains,' as "an Echinite from Kent with its spine;" he gave no description of the specimen, and it was reserved for Dr. Mantell, 1822, to give it a specific place among our Cretaceous Urchins.

The long list of synonyms prefixed to this article exhibits the historical phases through which it has passed, and the numerous admirable and accurate drawings with which our excellent friend Mr. C. R. Bone has enriched our Monograph will make the determination of *Cyphosoma Königi* a matter of ease and certainty to all future observers.

The specimen figured Pl. XXIII, figs. 1 *a*—*g*, belongs to the British Museum. The large test is subcircular, slightly convex above, inflated at the sides, and flattened below (fig. 1 *c*); the surface is highly ornamented, the tubercles are nearly all of the same size and regular in their disposition, and the granules are large and conspicuous at the base.

The ambulacral areas are narrow above, wide at the ambitus, and contracted at the base; they possess two rows of tubercles, 12 or 13 in each row; those at the ambitus are very large, and nearly equal in size the inter-ambulacral tubercles; on the upper third of the area they diminish rapidly in magnitude, and from the ambitus to the peristome are much larger.

At the ambitus the areolæ are wide and confluent, but on the upper surface they are narrow and separated only by a line of granules; the zone which divides the two series is

contracted, and provided with two rows of granules closely set together, unequal in size, some of them being mammillated at the angles of the plates.

The poriferous zones are narrow and undulated at the base and ambitus, and wide and straight at the upper surface; the pores are small, and unigeminal from the peristome to the ambitus (fig. 1 *e*), and distinctly bigeminal on more than the upper third of the zones (fig. 1 *d*); near the peristome the pairs are doubled (fig. 1 *g*).

The inter-ambulacral areas are about one third wider than the ambulacral, and furnished with primary and secondary tubercles; the primary series consists of two rows, twelve in each, occupying the centre of the plates; the tubercles are smaller on the upper than on the lower third of the area; the secondary tubercles are large and unequal in size; they form a series between the poriferous zones and primary tubercles, some of which they resemble in magnitude, especially those extending from the ambitus to the coronal plates; between the ambitus and peristome they are much smaller, and in many specimens are not more developed than large granules on mammillated eminences.

The miliary zone is very wide, naked, and depressed at the upper surface, becoming gradually narrower at the ambitus, and much contracted at the base; the granules, unequal in size, are fine, abundant, set closely together, and arranged in semicircles around the primary and secondary tubercles; some of the granules, much larger than the others, are set on mammillated eminences, and may easily be mistaken for the small secondary tubercles placed near them; this mingling together of small tubercles and large mammillated granules imparts a highly ornamented character to the infra-marginal region of this species.

Discal opening large, pentagonal, and subangular, the elements wanting in all the specimens hitherto found. Mouth-opening small, circular, the peristome feebly incised, the border reflected, the entailles having the border elevated and opening upwards.

The spines exhibit some remarkable variations from the typical form of structure. Some of the most curious of these I have figured in Pls. XXIV and XXVI. The typical spines, as seen in those *in situ* in the specimen belonging the British Museum (Pl. XXIV, fig. *a*), are elongated, subcylindrical, and sometimes aciculate at the summit (fig. 1 *d*, and fig. 3 *a*), or spatuliform with carinæ, as Pl. XXIV, fig. 1 *c*, or spoon-shaped, as Pl. XXVI, figs. 1 *a*, *b*, the lower part or collerette being long and distinct, and covered with fine longitudinal lines (Pl. XXIV, fig. 3 *b*), much stronger than those observed on the stem; the head is well developed, the milled ring very prominent, flat, and deeply striated, and the rim of the acetabulum finely crenulated (Pl. XXVI, figs. 1 *a*, *c*, figs. 2, 4, 6), with other varieties of spines figured in this plate.

The test of this Urchin presents many variations of form from the typical shape seen in the specimen figured in Pl. XXIII, fig. 1 *a*, *b*, and considered to be its normal form. In Pl. XXIV, fig. 7, I have figured a remarkable monstrosity of this species from the British Museum Collection; it is inversely conical, like *Pseudodiadema tumidum;* measures three quarters of an inch in height, and is one inch and one third in diameter

above, contracting below down to the oral opening, which, at first sight, appears to be the summit of the test. In Pl. XXII, figs. 5 *a*, *b*, *c*, I have given drawings of a young test from the National Collection.

Affinities and Differences.—This species forms one of the most typical forms of the genus *Cyphosoma*, well characterised by its large size, round and inflated at the ambitus, highly ornamented at the base, and having the poriferous pores distinctly bigeminal in all the upper part of the zones; the secondary tubercles are large above the ambitus and small at the base; the spines are strong, elongated, and furnished with a striated collar, having the summit sometimes flattened and carinated, or expanded and spatulate, as seen in the different figures.

The nearest affinities of *C. Königi* are with *C. granulosum*, from which it differs in having large secondary tubercles above the ambitus and a more ornamented test at the base. In size and height, and in the disposition of its tubercles on the upper surface, as well as in the bigeminal arrangement of the pores in the upper part of the zones, it much resembles *C. magnificum*, Agass., from the Étage Sénonien inférieure of the south-west of France.

Locality and Stratigraphical Position.—*C. Königi* is found in fine preservation in the Upper Chalk of Kent, Sussex, Norfolk, Wiltshire, and Yorkshire. In France it is collected in the Étage Sénonian at Thuison (Somme); Tartigny (Oise); Vernonnet, La Villette, Hougouemarre (Eure); where it is rare. It is likewise found at Rügen, and Cæsfeld, near Dusseldorf.

Cyphosoma corollare, *Klein*. Pl. XXVI, figs. 7, 8, 9, 10.

Echinites orbiculatus,	*Lister*.	Hist. Animal. Angliæ, p. 220, pl. vii, fig. 19, 1678.
Cidaris corollaris,	*Klein*.	Natur. Dispos. Echinoderm., pl. viii, fig. c, p. 20, 1734.
— —	*Baier*.	Oryctographia Norica, p. 70, pl. iii, fig. 36, 1759.
— —	*Leske*.	Klein, Nat. Dispos. Echinoderm., p. 138, pl. viii, fig. c, 1778.
— coronalis,	*Gmelin*.	Linné's System. Natur., p. 3177, 1788.
Echinus saxatilis,	*Parkinson*.	Organic Remains, pl. iii, fig. 1, 1811.
Cidaris corollaris,	*Parkinson*.	Ibid., pl. i, fig. 7, 1811.
— saxatilis,	*Mantell*.	Geology of Sussex, p. 180, 1822.
— corollaris,	*Mantell*.	Ibid., p. 181, 1822.
Echinus saxatilis,	*Fleming*.	History of British Animals, p. 479, 1828.
— —	*Brongniart*.	Tableau des Terrains, p. 405, 1829.
— —	*Woodward*.	Synop. Table of Brit. Org. Remains, p. 6, 1830.
— —	*De Blainville*.	Zoophytes, Dict. des Sc. Nat., t. lx, p. 210, 1830.
Cidaris corollaris,	*Agassiz*.	Prodrome des Radiaires, p. 188, 1836.
Echinus corollaris,	*Desmoulins*.	Études sur les Échinides, p. 298, 1837.

Cidaris corollaris,	*Morris.* Catalogue of British Fossils, p. 49, 1843.
— saxatilis,	*Morris.* Ibid., p. 50, 1843.
Cyphosoma corollare,	*Agassiz* et *Desor.* Catal. Rais. des Échinides, p. 351, 1846.
Cidaris corollaris,	*Bronn.* Index Palæontologicus, p. 298, 1848.
— saxatilis,	*Bronn.* Ibid., p. 300, 1848.
Cyphosoma corollare,	*D'Orbigny.* Prodrome, t. ii, p. 273, Ét. 22, 1850.
— —	*Forbes.* In Dixon's Geol. of Sussex, p. 340, 1850.
— —	*Forbes.* In Morris's Catalogue of Brit. Foss., p. 75, 1850.
Phymosoma —	*Desor.* Synop. des Échinides fossiles, p. 88, 1856.
Cyphosoma saxatile,	*Desor.* Ibid., p. 87, 1856.
— corollare,	*Pictet.* Paléontologie, 2e éd., t. iii, p. 243, 1857.
— —	*Woodward.* Mem. Geol. Surv., Decade V, p. 2, 1858.
— —	*Leymerie* et *Raulin.* Géol. du Départ. de l'Yonne, p. 621, 1858.
Phymosoma saxatile,	*Dujardin* et *Hupé.* Hist. des Echinoderm., p. 508, 1862.
— corollare,	*Dujardin* et *Hupé.* Ibid.
Cyphosoma perfectum,	*Cotteau* et *Triger.* Échinides de la Sarthe, p. 261, pl. xlii, figs. 13—16, 1860.
— —	*Cotteau.* Échinides foss. des Pyrénées, p. 24, 1863.
— corollare,	*Cotteau.* Pal. Française, t. vii, p. 669, pl. 1165, 1864.

Test small, circular, depressed; ambulacra wide, two rows of tubercles, nine to ten in each, gradually diminishing in size towards the poles; inter-ambulacra moderate, with two rows of tubercles, nine in each, four ambital, large; areolæ defined by rows of granules; miliary zone moderate, granular below, becoming smooth above; poriferous zones narrow, undulated, pores unigeminal, and crowded near the summit; base concave; oral opening small, one third of an inch in diameter; discal opening large, pentagonal, half an inch in diameter; spines long, slender, spatulate, one fourth longer than the diameter of the test.

Dimensions.—Transverse diameter one inch; height one third of an inch; in general the specimens are not so large.

Description.—This is one of our most common *Cyphosomata.* In certain localities it is a small, circular Urchin, rarely exceeding an inch in diameter and about three or four lines in height; it is convex and depressed above, and flat or subconcave below; the areas are nearly equal in width, the tubercles very much alike in form and size, the areolæ are encircled with granules, and the structure of the different divisions of the test is very uniform throughout.

The ambulacral areas (Pl. XXVI, fig. 10), contracted above by the poriferous zones, have two rows of primary tubercles supported on large bosses, and arranged in alternate series on each side of the area; in adult specimens there are nine or ten tubercles in a row; the areolæ are wide, and a single row of granules (rarely double) separates them from each other.

The poriferous zones are narrow, and much undulated at the ambitus and infra-mar-

ginal region; the small pores are arranged in oblique pairs at the sides, and at the upper surface become bigeminal; fig. 10 shows an ambulacral area with its poriferous zones magnified six diameters; fig. 7 *b* exhibits the upper part of the area magnified six times, with the bigeminal arrangement of the pores in the upper part of the zones.

The inter-ambulacral areas are furnished with two rows of tubercles nearly identical with those of the ambulacral; they are, however, a little larger than the latter in the upper surface, and are surrounded by areolæ that are placed wider apart. The secondary tubercles are very small and unequal in size; they form a series near the zones, one mammillated tubercle rising in each plate from the midst of numerous granules. They are most apparent at the lower surface and the ambitus, and are rare on the upper surface.

The miliary zone is wide, naked, and depressed in the upper surface, forming at the ambitus and lower surface a zigzag line, which defines the contour of the plates. The granules are large, and those surrounding the primary tubercles at the ambitus send prolongations into the areolæ, which impart a radiated character to the structure of these parts. The intermediate granules are more or less abundant, and form circles or semicircles around the areolæ. The small mouth-opening is lodged in a concave depression in the base. The peristome is circular, and divided by feeble incisions, the lobes of which are nearly equal. The apical disc is absent. The opening is large, pentagonal, and angular, and in our large specimen is about five lines in diameter.

The spines are long, slender, and spatulate, one fourth longer than the diameter of the test, to which they are sometimes found adherent and *in situ*.

Affinities and Differences.—*C. corollare* is readily recognised by its moderate size, depressed circular test, sometimes subpentagonal; the pores are unigeminal on the sides and bigeminal on the upper surface, with small secondary tubercles at the base near to the zones; the miliary zone is nude and depressed near the summit; the mouth-opening is small, and lodged in a concave depression. By these characters it may be distinguished from *C. tiara* and young examples of *C. granulosum*, both of which it resembles much.

Locality and Stratigraphical Position.—This Urchin is very common in the upper flinty Chalk of Brighton, Gravesend, and Woolwich. In France M. Cotteau enumerates the following localities in which it is rarely found in the Étage Sénonien:—Senneville, Saint-Pierre en Port (Craie supérieure, M. Hebert); Seine Inférieure, La Herelle (Oise); Pinterville (Eure); Villeneuve-sur-Yonne (Yonne); Meudon (Seine-et-Oise); Sarlat (Dordogne); Tercis (Landes).

History.—The history of this species, one of the oldest Cyphosomas, is very difficult to trace, as our table of synonyms has already exposed. Lister and Klein have both figured it, and Parkinson has given a very good figure of it under the name of *Echinites saxatilis* in his 'Organic Remains.' Klein's name, however, has the priority, and therefore is retained.

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ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART FOURTH.

ON THE DIADEMADÆ AND SALENIDÆ.

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CYPHOSOMA MAGNIFICUM, *Agassiz*, 1840. Pl. XXV, figs. 1, 2 *a*, *b*, *c*, *d*, *e*.

CYPHOSOMA MAGNIFICUM,	*Agassiz*. Catal. Syst. Ectyp., p. 11, 1840.
— SULCATUM,	*Agassiz* et *Desor*. Catal. raison. des Échinides, p. 351, 1846.
— MAGNIFICUM,	*Bronn*. Index Palæontol., p. 381, 1848.
PHYMOSOMA —	*Desor*. Synops. des Échinides foss., p. 88, 1856.
— SULCATUM,	*Desor*. Ibid., p. 90, 1856.
CYPHOSOMA MIDDELTONI,	*Woodward*. Mem. Geol. Surv., Decade V, App., p. 4, 1856.
— SULCATUM,	*Pictet*. Traité de Paléontol., 2e éd., t. iv, p. 243, 1857.
— —	*Cotteau* et *Triger*. Échinides de la Sarthe, pl. 44, fig. 9, 1860.
PHYMOSOMA —	*Coquand*. Synops. des Foss., Bull. Soc. Géol. de France, t. xvi, p. 992, 1860.
PHYMOSOMA —	*Dujardin* et *Hupé*. Hist. Nat. Zooph., p. 508, 1862.
CYPHOSOMA —	*Bourgeois*. Espèces Ter. Crétacés, Bull. Soc. Géol. France, deux. sér., t. xix, p. 674, 1862.
— MAGNIFICUM,	*Cotteau*. Échinides foss. des Pyrénées, p. 25, 1863.
— —	*Cotteau*. Paléontologie Française; Ter. Crétacé, t. vii, p. 635, pls. 1155-56-57, 1865.

Test circular, elevated, sides tumid, base concave; poriferous zones narrow, undulated, pores unigeminal; primary tubercles of both areas large at the base and ambitus, and small on the upper surface; areolæ large and confluent at ambitus and base, very small above; upper third of inter-ambulacra bordered with a row of small secondary tubercles; miliary zone wide, sulcated, and nude above; mouth-opening small, peristome equal-lobed; discal opening very large, pentagonal, angular, and elongated.

Dimensions.—A. Figured specimen, latitude ten lines; altitude six lines.

B. Specimen in my cabinet, latitude one inch; altitude half an inch; discal opening (antero-posterior diameter) six tenths of an inch.

Description.—This very rare British *Cyphosoma* was obtained by J. Middleton, Esq., from the Upper Chalk, near Norwich, and placed in the hands of the late Professor Edward Forbes for description, whose manuscript name for the same was *C. Middeltoni*. Under this designation a diagnosis of the species was given by my late friend Dr. Woodward, in his valuable appendix to Decade V of the 'Memoirs of the Geological Survey,' who kindly obtained another specimen, to enable me to give a detailed description of this rare British form; a careful examination of this fossil, however, has satisfied me that it is merely a small variety of *Cyphosoma magnificum*, Agassiz, and agrees in all its specific characters with the sulcate variety of that species.

The test is circular, elevated, or moderately depressed on the upper surface, inflated at the sides (Pl. XXV, figs. 1 *a* and *d*) and concave at the base (fig. 1 *c*). The ambulacral

areas are wide, with two rows of tubercles, which are large at the ambitus and base and very small on the upper surface; the change from the large ambital to the small dorsal tubercles is very abrupt; the areolæ of all the large tubercles are wide and confluent, and those of the smaller are surrounded by circlets of granules.

The poriferous zones are narrow, and much undulated at the ambitus and infra-marginal region; they are less sinuous above, where the pores are small and unigeminal; the spaces between the pairs of holes often support two small granules (fig. 1 *e*).

The inter-ambulacral areas are about one third wider than the ambulacral, and provided with two rows of primary tubercles, twelve in each, nearly identical with those in the ambulacra; like them, they have wide areolæ at the ambitus and infra-marginal region, and very small on the upper surface; the transition from the large ambital to the small dorsal tubercles is likewise well marked in the specimen before me (fig. 1 *a*, *d*). A row of small irregular secondary tubercles, five or six in each, occupies the spaces between the primary series and the poriferous zones (figs. 1 *b*, *d*), and disappears among the granules of this region. Other secondary tubercles occupy the wide spaces by the zones at the angles of the plates (figs. 1 *c*, *e*, and figs. 2 *a*, *b*), and range in file with the small secondary series on the upper surface. The intermediate granules are large and abundant, of unequal size, and disposed in circles around the areolæ; these circles at the ambitus are incomplete at their basal border (fig. 1 *e*). The miliary zone is large, much depressed in the middle, and nude as it approaches the discal opening (fig. 1 *d*); the small granules forming complete circlets around the small tubercles of this region.

The primary tubercles at the under surface are moderately large, and nearly the same size in both areas (fig. 1 *c*, and fig. 2 *b*), which imparts a highly ornamented character to this region of the test and contrasts strongly with the small tubercles, and the naked and depressed miliary zone on the upper surface (fig. 1 *d*).

The mouth-opening is small, the peristome circular, and divided into nearly equal-sized lobes by feeble incisions (fig. 1 *c*). The discal opening is large, pentagonal, angular, and elongated in the antero-posterior direction (fig. 1 *b*).

Cyphosoma magnificum, so rare in England, is a very common species in the south-west of France, where two well-marked varieties are found. The *first type of the species* is characterised by having its ambulacral and inter-ambulacral tubercles large and prominent at the ambitus, becoming gradually smaller on the upper surface, the miliary zone wide and not depressed in the middle. In the *second type* the transition in size from the large ambital to the small dorsal tubercles is more abrupt, the upper part of the miliary zone is quite destitute of granules and much depressed in the middle, near the coronal plates, which are marked with very distinct sutures; the areolæ at the ambitus are larger and more superficial, and the under surface has a more ornamented appearance. This variety has been described as *C. sulcatum*, and is that to which our specimen is referred. It attains a much larger size than the first or type form, as a specimen collected from the Chalk of Royan

(Charente-Inférieure) measures two and a half inches in diameter, and one inch and one tenth in height.

The English specimens of this Urchin that have hitherto been collected are small and immature, they consequently have fewer tubercles in each row than the French specimens possess, and the poriferous zones, for a like reason, have the pores in single file, the bigeminal arrangement being a character of more mature age.

Affinities and Differences.—This species differs so much from its English congeners that it is readily distinguished from all of them by its wide ambital areolæ and large tubercles, and the series of small tubercles on the upper surface, with a secondary row on the zonal side. In its general characters *C. magnificum* resembles *C. Archiaci* from the same stage, but the latter has a more pentagonal test, wider inter-ambulacral areas, smaller primary tubercles, and four rows of secondary tubercles; the base likewise is flatter, and the mouth-opening larger and more superficial.

Locality and Stratigraphical Position.—The English specimens have been found only in the Upper Chalk at Norwich, where they are extremely rare.

M. Cotteau states that this species is common in the Etage Sénonien inf. at Saint-Pierre de Chevillé, Saint-Paterne, Saint-Calais, Marcon (Sarthe); Villers, Villedieu (Loir-et-Cher); Saint-Christophe, Semblançy (Indre-et-Loire); Barbezieux, Aubeterre, Espagnac, près Angoulême, Charmant, Lavalette (Charente); Royan, Talmont, Saintes, Cognac (Charente-Inférieure), Saint-Georges près Perigueux, Tretissac (Dordogne); Belbèze (Haute-Garonne).

History.—The table of synonyms gives the history of this species, which was unknown to my old friend Professor Forbes, who named the only specimen he ever saw after the friend who communicated it for description.

Cyphosoma Wetherelli, *Forbes.* Pl. XXVII, figs. 1, *a*—*h*.

Cyphosoma Wetherelli, *Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 75, 1854.

— — *Woodward.* Mem. Geol. Surv., Decade V, Supplement, p. 2, 1856.

Test circular, inflated at the sides, depressed at the summit, and flat beneath; ambulacra wide, two rows of large tubercles, nine to ten in each, gradually diminishing in size towards the poles; inter-ambulacra, two rows of primary tubercles, nine in each, with a small secondary tubercle in the centre of the zonal margin of each plate; poriferous zones narrow, undulated; pores unigeminal throughout; mouth-opening one third the diameter of the test; discal opening large, angular, pentagonal.

Dimensions.—Transverse diameter one inch; height half an inch.

Description.—This Urchin very much resembles *C. corollare*, Klein, but was separated

from that species by the late Professor Edward Forbes, and dedicated to N. T. Wetherell, Esq., F.G.S., who presented it to the Museum of the Royal School of Mines. This unique typical example, partly imbedded in flint, was obtained at Gravesend. The test is of moderate size, has a circular figure, and is depressed a little above and below; the sides are inflated and the base is flat; the ambulacral areas are wide, with two rows of large tubercles (figs. 1 *c*, *b*), nine or ten in each; the areolæ occupy nearly the entire width of the plates, and are bordered by a series of prominent miliary granules, which are absent only on the zonal sides of the plates (figs. 1 *e*, *g*, *h*); the tubercles gradually diminish from the ambitus to the oral (fig. 1 *h*) and the discal apertures (fig. 1 *g*); the areolæ retain throughout, even to the smallest tubercles, the border of granules special to each (figs. *g*, *h*).

The poriferous zones are much undulated, and form a series of crescents around the large tubercles (fig. 1, *d*); the rows are narrow, the pores simple and unigeminal throughout, and there are from five to six pairs of holes opposite each of the large plates (figs. *e*, *g*, *h*).

The inter-ambulacral areas, a little wider than the ambulacral, have two rows of primary tubercles, nine in each, and two rows of secondary tubercles placed near the zones, and extending from the peristome to the ambitus (fig. 1 *c* and fig. 1 *h*). The areolæ of the primaries are wide, occupying nearly the whole surface of the plates, and each is bordered by a row of distinct miliary granules (fig. 1 *e*), which completely separates the areolæ from each other. The secondary tubercles are small, and form a short row of twelve tubercles set on bosses; they occupy a space between the zones and the primary tubercles (figs. 1 *c*, *h*), and extend from the peristome to the ambitus.

The tubercles of both areas are very prominent, and nearly of the same size; the bosses are large, with feebly crenulated summits, closely embracing the mammillon, which is large and conspicuous (figs. 1 *e* and *f*).

The miliary zone is narrow at the ambitus, with two rows of granules; on the upper surface it becomes wider, depressed, and nude in the middle, and is sparsely supplied there, and at the sides, with very small granules (fig. 1 *b*).

The mouth-opening, small and circular, is one third the diameter of the test; the peristome is divided into ten nearly equal-sized lobes, by well defined incisions (fig. 1 *c*).

The discal opening is directly opposite to, and of the same proportional size as the oral aperture; it has a pentagonal form, and the single ovarial plate that extended into the single inter-ambulacrum protruded farther into this area than either the antero- or postero-lateral ovarials (fig. 1 *b*).

The upper surface of the test is considerably depressed, and the base is flat. This contour of the shell is well shown in fig. 1 *d*.

Affinities and Differences.—This species has the closest affinities with *Cyphosoma corollare*, of which it may, perhaps, prove to be only a variety. As it is at present a

unicum, we wait for the discovery of other specimens with spines before stating with confidence its affinitive relations.

Locality and Stratigraphical Position.—Found imbedded in a flint nodule at Gravesend, from the Upper Chalk.. The specimen belongs to the Museum of the Royal School of Mines.

CYPHOSOMA SPATULIFERUM, *Forbes*, 1850. Pl. XXVIII, figs. 1 *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*; Pl. XXIX, figs. 1 *a*, *b*, *c*, *d*.

CYPHOSOMA SPATULIFERUM, *Forbes*. Dixon's Geology of Sussex, pl. xxiv, fig. 20, p. 340, 1850.
— — *Forbes*. In Morris's Catalogue Brit. Foss., 2nd ed., p. 75, 1854.
— — *Woodward*. Mem. Geol. Surv., Decade V, Supplement, p. 2, 1856.

Test small, circular, inflated at the sides, concave at the base, and depressed on the upper surface; ambulacra prominent, two rows of tubercles, eight to ten in each; areolæ wide, bordered by granules; inter-ambulacra with two rows of primary tubercles, nine in each, and two short rows of secondary tubercles; areolæ wide, bordered by granules. Poriferous zones much undulated; pores unigeminal; tubercles of both areas nearly alike in size and structure. Mouth-opening one third the diameter of the test; discal aperture pentagonal, large and angular. Spines spatulate, very much flattened, smooth except near the base, where there are fine longitudinal lines.

Dimensions.—Height nine twentieths of an inch; transverse diameter seven tenths of an inch.

Description.—This beautiful little *Cyphosoma* has a circular body, with inflated sides and small projecting equal-sized tubercles; the ambulacral areas are prominent, and have two rows of tubercles; fig. 1 *f* shows one of these segments magnified six times; the areolæ are wide, and fill nearly the entire plate; the inner and upper margins of each are bordered by a series of miliary granules, which define the boundary of the areolæ, and entirely prevent them becoming confluent. The tubercles at the ambitus are a little larger, and they gradually become smaller as they approach the two apertures. The narrow poriferous zones are much undulated, and form a series of crescents around the large plates; there are, in general, six pairs of holes opposite each plate, and they are entirely unigeminal throughout (fig. 1 *f*).

The inter-ambulacral areas are a little wider than the ambulacral, and composed of large plates (Pl. XXVIII, fig. 1 *g*; Pl. XXIX, fig. 1 *d*), of which there are nine in each column. The areolæ are wide, and bordered by a circle of miliary granules, complete on five sides of the plate, but absent on lower margin (Pl. XXIX, fig. 1 *d*). The miliary zone is

narrow at the ambitus, where it is crowded with granules, and wide at the upper surface, where it is depressed and nearly nude (Pl. XXVIII, fig. 1 *b*). At the base of the area, between the primary tubercles and the poriferous zones, there is a short row of small secondary tubercles (fig. 1 *c*), which extends from the peristome to the ambitus; fig. 1 *h* shows the base of this segment magnified six times; the small secondaries are raised upon bosses (fig. 1 *h*).

The tubercles of both areas are nearly of the same size; the boss is large, with feeble crenulations, closely embracing the mammillon, which is very prominent (Pl. XXIX, fig. 1 *d*).

The base is concave, and the mouth-opening, one third the diameter of the test, is in a slight depression (fig. 1 *c*). The peristome is divided by slight incisions into ten nearly equal-sized lobes. The discal opening is large and pentagonal. The mould of the single ovarial plate descends further into the segment than either the antero- or postero-lateral ovarials into their respective areas.

The spines of this Urchin are spatulate, and the stem is extremely smooth, except near the milled ring, where the base is marked by fine longitudinal lines.

Affinities and Differences.—The spatulate form of the spines distinguish this species from *C. corollare*, with which it has many affinities in the anatomy of the test; *C. spatuliferum* is, however, a smaller Urchin, more compressed and pentagonal, less inflated at the sides, and more depressed on the upper side than *C. corollare;* the surface of the test is, likewise, rougher in consequence of the numerous small tubercles that project sharply from the plates.

Locality and Stratigraphical Position.—This is a rare species in the Upper Chalk of Kent and Sussex. The type specimens of the Dixon Collection are now in the British Museum. One of these I have figured in Pl. XXVIII, fig. 1; and a still larger specimen, from the Rev. T. Wiltshire's Cabinet, in Pl. XXIX, fig. 1.

CYPHOSOMA RADIATUM, *Sorignet*, 1850. Pl. XXIX, figs. 2 *a*, *b*, *c*; figs. 3 *a*, *b*.

CYPHOSOMA ? (small or young), *Dixon*. Geol. Sussex, p. x, pl. xxiv, figs. 28—31, 1850.
— RADIATUM, *Sorignet*. Oursins foss. du Dép. de l'Eure, p. 28, 1850.
— SIMPLEX, *Forbes*. Morris's Catalogue of Brit. Foss., p. 74, 1854.
— — *Woodward*. Mem. Geol. Surv., Decade V, App., p. 1, 1856.
PHYMOSOMA HEBERTI, *Desor*. Synopsis des Échinides foss., Supplément, p. 450, 1858.
CYPHOSOMA PERFECTUM, *Cotteau* et *Triger* (pars). Échinides du Départ. de la Sarthe, p. 375, 1862.
PHYMOSOMA HEBERTI, *Dujardin* et *Hupé*. Hist. Nat. des Echinoderm., p. 508, 1862.
— SIMPLEX, *Dujardin* et *Hupé*. Ibid.
CYPHOSOMA RADIATUM, *Cotteau*. Paléontologie Française; Ter. Crét., pl. 1147, figs. 10—14; pl. 1148, p. 609, 1864.

Test small, subpentagonal, convex above, base concave; ambulacra, two rows of

tubercles, eight in each, with large confluent areolæ at the ambitus; inter-ambulacra, two rows of primary tubercles, nine to ten in each, with two short rows of small secondaries at the base; primary tubercles prominent at the ambitus, small and inconspicuous above; areolæ large, radiated, and nearly confluent at the middle, very small above; poriferous zones undulated, unigeminal; pores small.

Dimensions.—Height three tenths of an inch; transverse diameter six tenths of an inch.

Description.—This beautiful little species occurs in the hard gritty Chalk of Dover. The test is more highly ornamented than any of the preceding forms; the tubercles at the ambitus are highly developed, with radiated areolæ, and nearly all of the same size. On the upper surface they are proportionally small. The ambulacral segments slightly project; this imparts a subpentagonal form to the body (fig. 2 *a*). There are two rows of tubercles therein, eight in each, those at the ambitus being very large, and those on the upper surface very small (fig. 2 *c*). The areolæ of the large ambital tubercles are confluent, and the smaller ones are separated from each other by a few granules (fig. 2 *c*).

The poriferous zones are narrow and much undulated (fig. 3 *a*); at the ambitus the pores are small and unigeminal, and there are five pairs opposite each of the larger plates.

The inter-ambulacral areas are a little wider than the ambulacral, with two rows of tubercles, nine to ten in each. The areolæ are wide; those at the ambitus and superior surface have a radiated border at the circumference, the radii being formed of elongated granules developed into a pyriform shape; (fig. 3 *b*) represents four central plates of an inter-ambulacral segment magnified eight times. In some of the plates small miliary granules are introduced within the rayed circle.

The discal opening is large, and of an elongated pentangular shape; the angle corresponding to the single inter-ambulacrum projecting far down that segment (figs. 2 *a* and *b*).

Affinities and Differences.—This species in its general facies resembles *C. spatuliferum*, but differs from it in having the tubercles on the upper surface disproportionately small when compared with the large size they attain at the ambitus (figs. 2 *b*, *c*). This character is very evident when fig. 2 *c*, Pl. XXIX, is compared with fig. 1 *f*, Pl. XXVIII. The radiated structure of the areolæ is likewise another good diagnostic character between these nearly allied forms. M. Cotteau appears to consider *C. Wetherelli* and *C. spatuliferum* as varieties of *C. striatum;* but, after a careful comparison of the specimens themselves and with each other, I must dissent from this opinion. However much the tests of *Echinidæ per se* may resemble one another, still we must not forget that the shell alone is not the complete body of the animal, and that without its spines our evidence of specific identity is incomplete: for example, the test of *Hemicidaris crenularis*, Ag., is identical with *Hemicidaris intermedia*, Flem.; but the spines of the former are very different

from those of the latter, and without these appendages it is impossible to distinguish the test of the one Urchin from that of the other, and the same conditions may be true of the tests of other, nearly allied forms. *C. Wetherelli* may be considered a variety of *C. corollare* until proof to the contrary is discovered; but the structure of the test of *C. spatuliferum* and the remarkable form of its flattened spines, when compared with the test and spines of *C. corollare*, afford presumptive evidence that they are distinct forms. It is very desirable to diminish the number and correct the synonyms of species in our lists; to do this, however, correctly requires much literary research and a critical examination and comparison of the specimens themselves, before a true solution of the difficulty can be arrived at; and in doing all this the best observers very often confuse analogy with identity of structure, from the imperfect materials upon which they are too often obliged to work.

Locality and Stratigraphical Position.—Cyphosoma striatum is usually found in the hard, gritty beds of Lower Chalk near Folkestone, and occasionally in the Upper Chalk with flints in Sussex.

The type specimen figured in Pl. XXIX belongs to the Museum of the Royal School of Mines. I have examined several others collected by my kind friend, the Rev. T. Wiltshire, F.G.S., from the Lower Chalk, near Folkestone, where he found it associated with *Salenia granulosa*, Forb.

SALENIDÆ.

Family 5.—Salenidæ, *Wright*, 1856.

This natural family nearly corresponds to the Salénies of MM. Agassiz and Desor, and is distinguished from other families of the *Echinodea Endocyclica* by the peculiar structure and great development of the apical disc, which, besides the five genital and five ocular plates, has an additional or sur-anal plate, developed in the centre of the disc, immediately before the anal opening; this plate in some genera is single, in others it is composed of from one to eight separate elements.

The test is thin, and in general small, spheroidal, hemispherical, or depressed; the ambulacral areas are always narrow, straight, or flexuous, with two rows of granules or small tubercles, that alternate with each other on the margins of the area.

The poriferous zones are narrow; the pores unigeminal, except near the peristome, where they fall into oblique ranks of threes.

The inter-ambulacral areas are wide, with two rows of primary tubercles, which have large bosses and crenulated summits; in *Acrosalenia* and *Pseudosalenia* the tubercles are perforate, in *Peltastes, Goniophorus*, and *Salenia* they are imperforate. The mouth-opening differs in size in the different genera; the peristome is more or less decagonal, and

sometimes deeply notched, or only feebly indented. The jaws are known in one genus, in which they resemble those of *Hemicidaris*.

The spines in *Acrosalenia* are long, slender, angular, or flattened, and the surface of the stem, although apparently smooth, is covered with very fine longitudinal lines. In *Pseudosalenia* they are enlarged, ovoid, sub-glandiform, and more or less granular; in *Peltastes* and *Salenia* they are elongate, aciculate, straight, curved, or bent.

From a misconception of the true relative position of the elements of the apical disc in this family, much confusion exists in the works of different authors in the description of this part of the test. "The great difficulty in the study of this group," says M. Desor,[1] "is to find the place of the madreporiform body; we are consequently embarrassed when we attempt to assign the lateral parts to the longitudinal axis of these animals, unless we admit that the sur-anal replaces the madreporiform body; but this would be contrary to all analogy, because in all the other Cidarides the madreporiform body is an integral part of one of the genital plates. M. Agassiz got rid of the difficulty by means of an hypothesis, by admitting that the sur-anal plate is invariably placed in the plane of the animal, that it therefore could only be anterior or posterior; hence his two divisions in the genus *Salenia*, the first with a sur-anal plate posterior, and, consequently, with the *périprocte* excentral and before; the second with the sur-anal plate anterior, and, consequently, with the *périprocte* excentral and behind."[2]

Professor Johannes Müller assigns the left posterior genital plate as the bearer of the madreporiform body in *Salenia personata*. "Dies wird auch durch die Salenien bestätigt, wo die Längsachse durch die plaque suranale vor dem After bestimmt wird. An einem im mineralogischen Museum aufbewahrten ausgezeichnet schönen Exemplar der *Salenia personata*, Ag., mit vorderem After, Taf. I, fig. 9, ist die linke hintere Genitalplatte porös und Madreporenplatte."[3]

I have selected fine specimens of *Peltastes Wrightii*, Desor, from the Lower Greensand, *Peltastes Austeni*, Forbes, from the Lower Chalk, and *Salenia petalifera*, Desmarest, from the Upper Greensand, and in all of these the madreporiform body occupies the surface of the right anterior genital plate, as in the *Cidaridæ*, *Hemicidaridæ*, *Diadematidæ*, and *Echinidæ*. The sur-anal plate is central, and the anal opening posterior in a line with the axis of the body, or inclined to the right side. In fact, the madreporiform body and sand canal, whatever their true functions may be, have the same position in all the Echinidea, recent and fossil, which I have examined, and probably the same in all Echinodermata. Professor Müller's mistake, therefore, may have arisen from placing the *Salenia* in a false position before him. The study of the apical disc in the *Acrosalenia* reveals the true relation of its elements to each other, and proves that the sur-anal plate

[1] 'Synopsis des Échinides fossiles,' p. 138.

[2] For further details on this subject, M. Agassiz's 'Monographies d'Échinodermes: première Monographie des Salénies,' may be consulted.

[3] Joh. Müller, 'Ueber den Bau der Echinodermen,' p. 7.

has nothing in common with the spongy madreporiform body which occupies the surface of the right anterior genital plate (Pl. XV, fig. 4, *a*, *i*). I had the good fortune to make this discovery some years [1] ago, when figuring and describing *Acrosalenia hemicidaroides*, which urchin has furnished a key to the true relation of the bilateral parts to the longitudinal axis of the SALENIDÆ. On this point M. Desor observes:

"Nous devons en outre à M. Wright une autre découverte plus importante, celle du corps madréporiforme, qui fait partie intégrante de l'une des plaques génitales comme dans les autres Cidarides. Or comme nous savons maintenant que cette plaque a une position fixe dans tous les oursins, nous sommes par là même en mesure de déterminer l'avant et l'arrière de ces animaux; et puisque les plaques sur-anales sont situées en arrière de cette plaque, il s'ensuit que le périprocte se trouve réellement refoulé en arrière. Il ne peut dès-lors plus être question d'Acrosalénies à périprocte eccentrique en avant, comme on supposait que c'était le cas de l'*Acrosalenia tuberculosa*." &c.

"Il n'arrive que trop souvent que le disque apicial manque, et dans ce cas, il est très difficile de distinguer les Acrosalénies du genre Hemipedina decrit-ci-dessus. Cependant, comme par suite du refoulement du périprocte en arrière la plaque genitale impaire ou postérieure gagne plus que les autres sur le test, on peut encore, d'après M Wright, reconnaître la place de cette plaque même dans les individus dépourvus d'appareil apicial." [2]

A Table showing the Classification of the SALENIDÆ.

Family.	Sections.	Diagnosis.	Genera.
SALENIDÆ.	*Section* A. Tubercles perforated. Apical disc small.	Ambulacral areas straight, large, with two rows of small tubercles; apical disc small and not prominent; sur-anal plate composed of one or many pieces granulated on the surface; vent posterior and central in the axis of the test; spines long.	*Acrosalenia*, Agassiz.
		Ambulacral areas narrow, flexed, with two rows of granules; apical disc prominent, not granulated, and marked with impressions; vent excentral posterior, in the axis of the test; spines enlarged, ovoid, sub-glandiform, more or less granular.	*Pseudosalenia*, Cott.
	Section B. Tubercles imperforate. Apical disc large, shield-like, and prominent.	Inter-ambulacral tubercles moderate; apical disc large and prominent; genital plates in the form of elongated lobes; sur-anal plate single; vent posterior and central in the axis of the test.	*Peltastes*, Agassiz.
		Inter-ambulacral tubercles large, few in number; apical disc large, and forming a regular pentagon, with elevated angular carinæ independent of the sutures; sur-anal plate angular; vent large, excentral, oblong, and posterior.	*Goniophorus*, Agassiz.
		Inter-ambulacral tubercles large; apical disc wide and very solid, with an undulated circumference; surface of the large plates ornamented with punctuations or sculptured figures along the line of the sutures; sur-anal plate single; vent posterior excentral and directed towards the right side.	*Salenia*, Gray.

[1] Wright, 'Annals and Magazine of Natural History,' 2nd series, vol. viii, p. 261.

[2] 'Synopsis des Échinides fossiles,' p. 140.

M. Cotteau thus describes the family "Salénidées," Wright:—Pores disposed in single pairs; ambulacra sometimes large, straight, and presenting a double range of small tubercles; sometimes narrow, and undulated, and garnished with granules; interambulacral tubercles few in number, largely developed, perforated, or imperforate, always crenulated. Peristome sub-decagonal and furnished with entailles. Periprocte excentric and posterior, placed in the axis of the animal or inclined a little to the right side. Apical disc very large, solid, most often marked with deep depressions, composed of five ovarial plates and five ocular plates perforated, with one or many sur-anal plates which determine the excentricity of the periprocte. Madreporiform plate distinct, different from the others by its spongy aspect and sometimes by a simple laceration, a fissure more or less large which corresponds to the genital pore and seems directed invariably to the left side. The spines are sometimes elongate, aciculate, or sub-cylindrical, furnished with fine longitudinal striæ in the *Acrosalenia hemicidaroides*, Wright, sometimes enlarged, ovoid, sub-glandiform, more or less granular, as in the *Pseudosalenia tuberculosa*.

The SALENIDÆ are divided into two natural groups.

1st. The *Acrosaleniæ* have narrow ambulacra gradually enlarged towards the oral aperture and provided with perforated tubercles more or less developed; the peristome is divided into two lobes by deep incisions; the apical disc is very large and provided with a sur-anal plate composed of one or many elements; in consequence of the number of small sur-anal plates, and their feeble union with each other, they are seldom preserved.

2nd. The *Saleniæ*, and the genera dismembered from them, have narrow ambulacra, often undulated and garnished with tubercles; their peristome is feebly incised; the apical disc is large and solid, projecting beyond the surface, and more or less deeply marked with impressions at the sutures of the plates.

The *Acrosaleniæ* resemble *Hemicidaris* and *Hypodiadema*, except in the structure of the apical disc, and when this portion is absent it is often difficult to determine the genus to which the mutilated specimen belongs; but the great size of the discal aperture, and the extension of the single ovarial plate into the single inter-ambulacrum readily enable the trained eye of the observer to distinguish it from *Hemicidaris*.

The *Saleniæ*, on the other hand, resemble the CIDARIDÆ by their narrow sub-flexuous ambulacra, furnished with granules, their wide inter-ambulacral areas, their large primary tubercles, and the inflated ovoid or sub-glandular spines, sometimes supported on them; their peristome is likewise feebly incised, like that of *Cidaris*.

The *Acrosaleniæ* form only a single genus, the species of which, with one exception, are distributed throughout the Jurassic rocks.

The *Saleniæ* have certain distinctive characters by which they are readily distinguished from the *Acrosaleniæ*. 1st. Their tubercles are all imperforate, and 2nd, the position of the vent, or periprocte, is always excentric and posterior; sometimes it is situated in the axis of the body, and sometimes out of the axis, and inclines to the right side. For this reason

MM. Agassiz and Desor have separated from the true *Saleniæ* the genera *Peltastes* and *Hyposalenia*. By the same authors a doubt has been suggested about the value of this character, as it may be only an accidental and variable condition; to this objection M. Cotteau replies, "that he has examined more than four hundred specimens of *Saleniæ* appertaining to the different stages of the Cretaceous formations, and representing almost all the known species, many among which, such as *Peltastes acanthoides*, *P. Studeri*, *Salenia petalifera*, *S. Prestensis*, and *S. Bourgeoisi* present characters that are clearly defined. Nevertheless we have recognised in each of those species that the periprocte, whether in the axis of the animal or out of the axis, occupies a place which is invariably the same."

The structure of the apical disc, and the lines and impressions marked thereon, afford a character of secondary importance, for although the general outline of these sutures is remarkably constant, still there are exceptions which show that caution must be exercised in using it, along with others, in the determination of species. The size of the ambulacra, and the number and magnitude of the granules contained therein; the form of the test, the size of the inter-ambulacral tubercles; the dimensions of the oral aperture, the structure of the peristome, and the depth of the incisions or entailles, collectively form good specific characters on which we can rely.

M. Cotteau divides the family Salenidæ into six genera, of which he gives the opposable characters in the following table.[1]

A. Ambulacra large, straight, furnished with small tubercles; apical disc with a compound sur-anal plate, the elements of which are covered with granules. — Acrosalenia.

B. Ambulacra narrow, sub-undulated, furnished with granules; apical disc large, prominent; sur-anal plate single; elements large shield-shaped, marked by regular impressions.

a. Tubercles perforated.

x. Periprocte excentral and posterior, situated in the axis of the animal — Pseudosalenia.

xx. Periprocte excentral and posterior, situated without the axis of the body — Heterosalenia.

b. Tubercles imperforate.

x. Periprocte excentral and posterior, situated in the axis of the animal.

1. Ambulacra destitute of poriferous impressions — Peltastes.

2. Ambulacra furnished with poriferous impressions — Goniophorus.

xx. Periprocte excentral and posterior, situated without the axis of the body and inclined to the right side — Salenia.

[1] 'Paléontologie Française; Terrain Crétacé,' tom. vii, p. 90.

The family Salenidæ commenced their life-career in the lower zone of the Inferior Oolite. *Acrosaleniæ* abound in the Inferior Oolite and the Cornbrash; and one is found in the Coralline Olite. *Pseudosalenia* was discovered in the Corallian of the Haut Jura. *Heterosalenia* is represented by one solitary species in the Chalk with Hippurites (Senonien Inférieur). *Peltastes* and *Goniophorus* are found chiefly in the Lower Cretaceous. *Saleniæ* occur in the Lower, Middle, and Upper Cretaceous rocks; and in the Tertiary Nummulitic limestone of Biarritz, are represented by a curious species, *Salenia Pellati*, recently found in that formation. Our present seas contain, we are told, a representative form of this family, which was recently dredged up off the American coast by the deep-sea dredging-operations performed in 1869; beyond the alleged fact I know nothing whatever of the genus to which this existing form belongs.

Genus—Peltastes, *Agassiz*, 1838.

Salenia (pars), *Agassiz*, 1838. Hyposalenia, *Desor*, 1856.

Test small, circular, more or less inflated above, and almost flat below; pores simple in the zone and crowded near the peristome; ambulacra straight, or slightly flexuous, furnished with two rows of small, close-set, homogeneous mammillonated granules. Inter-ambulacra large, provided with two rows of large, crenulated, imperforate tubercles.

Mouth-opening moderate in size, peristome divided into unequal lobes by feeble incisions. Periprocte excentral and posterior, situated in the line of the animal's axis. Apical disc shield-shaped, composed of large plates, more or less undulated at the border; the disc covers in general a large portion of the upper surface of the test, and is marked by sutural impressions and striæ that vary in the different species; the right antero-lateral ovarial plate has an oblong fissure always directed from right to left, corresponding to the oviductal pore and representing the madreporiform body.

Peltastes in its general form and structure resembles *Salenia;* it is distinguished from the latter, however, by the position and direction of the periprocte, which is excentral, and directed obliquely backwards and outwards and towards the right side; the ambulacra likewise are less flexed, the mouth-opening is smaller and lies in a deeper depression; the madreporiform fissure in the right antero-lateral ovarial plate is smaller.

The genus *Peltastes* was established in 1838 by Professor Agassiz; and in 1846 MM. Agassiz and Desor comprised in the genus all the Saleniadæ in which the periprocte was situated in a line with the axis of the animal, and this forms the leading character by which it is distinguished from *Salenia*.

The genus *Peltastes* is special to the Cretaceous formations; it commences with some remarkable forms in the Lower Greensand, appears in full force in the Upper Greensand and Lower Chalk; becomes rare in the Upper Chalk, and finally disappears from its upper stages.

A. *Species from the Lower Greensand or Neocomian.*

PELTASTES WRIGHTII, *Desor.* Pl. XXX, fig. 1 *a—f*, fig. 2.

SALENIA PUNCTATA,	*Forbes.* In Morris' Catalogue of British Fossils, 2nd ed., p. 89, 1854.
— —	*Woodward,* Memoirs of Geol. Surv., App. to Decade V, p. 7, 1856.
HYPOSALENIA WRIGHTII,	*Desor.* Synopsis des Échinides fossiles, p. 148, 1856.
PELTASTES —	*Cotteau.* Paléontologie Française; Terrain Crétacé, tome vii, pl. 1028, figs. 1—7.

Diagnosis.—Test circular, upper surface convex, sides inflated, under surface flat, ambulacra narrow, slightly flexuous, with two rows of granules fifteen in each, equal in size, and mammillated; poriferous zones slightly flexed, pores unigeminal, set in oblique pairs, and multiplied around the peristome; inter-ambulacra wide, with five or six large prominent tubercles, increasing in size from the peristome upwards. Apical disc very large, convex, subcircular, plates smooth, sutures marked with isolated points, periprocte transversely oblong, a little prominent; mouth-opening large, peristome divided by feeble indentations into ten lobes.

Dimensions.—Height six tenths of an inch; transverse diameter one inch.

Description.—This beautiful typical form of *Peltastes*, and the oldest we at present know, appears in our lists of English fossils as *Salenia punctata*, one of the synonyms of *Peltastes stellulatus*. A comparative study of specimens, however, convinced M. Desor that the identification was erroneous; and he described[1] our Farringdon urchin as a well-marked and distinct species, resembling *Peltastes stellulatus*, but separated from it in having a more inflated test, with more numerous and less prominent tubercles, the apical disc thinner and smoother, and marked only with some isolated punctations.

The test is circular, the sides are a little inflated, and the upper surface is convex and depressed; the ambulacral areas are narrow and very slightly flexed with two rows of mammillated granules, about fifteen in each. They are very uniform in size and arrangement throughout the area, except at the base, where two pairs are a little larger; a line of microscopic granules down the middle of the area divides the larger lateral rows from each other (Pl. XXX, fig. 1 *e*). The poriferous zones are wide for so small a test, and the pairs of pores are obliquely but very regularly arranged in a unigeminal series; near the peristome, however, they become a little more crowded and doubled.

The inter-ambulacral areas are wide, and in the large specimen I have figured fig. 1 *a*

[1] 'Synopsis des Échinides fossiles,' p. 148.

there are six plates in each column; the tubercles increase in size from the peristome upwards, so that the three upper pairs of tubercles are the largest and most prominent of the series (fig. 1 *d* and fig. 1 *f*). A few large mammillated granules, unequal in size, are arranged round the areola and in the miliary zone; a double row of smaller granules occupy the middle space; the tubercles are raised upon large bosses with deeply crenulated summits, and the mammillon is prominent, projecting, and imperforate (fig. 1 *f*).

The apical disc is very large, convex, subcircular, and entirely smooth, presenting in the line of its sutures two or three isolated superficial punctations in some of them (fig. 1 *b*); the sur-anal plate occupies the centre of the disc, and is situated immediately before the vent; in one example (fig. 2) however, it is abnormal and rudimentary, and forms an exceptional variety in an otherwise remarkably regular and symmetrical structure. Of the many specimens of this Urchin that have passed through my hands this is the only exception that has come under my notice. All the ovarial plates are perforated near the centres of each; the madreporic laceration is small, but very distinct in the right antero-lateral ovarial (fig. 1 *b*). The periproctc is sub-elliptical, rounded anteriorly, angular posteriorly, and somewhat elevated and inflated at the border (fig. 1 *b* and fig. 2).

The base is flat and the mouth-opening large, one half the diameter of the test (fig. 1 *c*). The peristome is circular and divided by feeble incisions into ten nearly equal-sized lobes.

Affinities and Differences.—This species presents great uniformity in its specific characters, after a careful examination of a great many specimens I have found very little variation from the type form I have figured and described. This specimen, belonging to the British Museum, is unexceptionally large, and perfect in all its parts. Smaller specimens are, however, equally good for description. The Sponge-gravel in which this Urchin is most commonly found is in general a very bad matrix for the preservation of the tests of Echinidæ; when shielded by a ferruginous crust, derived from the matrix, the more delicate portions of the urchin are wonderfully preserved. *P. Wrightii* resembles *P. stellulatus;* it is separated from that form by having a greater number of less prominent tubercles in the area; the apical disc is likewise thinner and smoother, and the sutural punctations are more isolated and more feebly marked.

Locality and Stratigraphical Position.—I have collected *Peltastes Wrightii* from the Sponge-gravel bed of the Lower Greensand near Farringdon, Berks; it has been found likewise in the Lower Greensand at Hythe, Kent; and at Atherfield and Sandown, Isle of Wight; it is, therefore, a true Neocomian or Lower Greensand form.

History.—This species is a very distinct form, and has been separated by Professor Desor from *P. punctatus*, with which it had been identified by most of our English authors. The accuracy of this determination has been sanctioned by M. Cotteau, who has given a very good description of the species, with excellent figures thereof, in his great work on the Cretaceous Echinidæ, in the 'Paléontologie Française.'

PELTASTES STELLULATUS, *Agassiz*, 1846. Pl. XXXI, figs. 1, 2, 3; Pl. XLI, fig. 1 *a—g*.

SALENIA STELLULATA,	*Agassiz*. Monog. des Salénies, pl. ii, figs. 25—32, p. 15, 1838.
— AREOLATA,	*Agassiz*. Ibid., pl. iii, figs. 1—8, p. 16.
— STELLULATA,	*Agassiz*. Échin. foss. de la Suisse, pl. xxiii, figs. 6—10, p. 90, 1840.
— AREOLATA,	*Agassiz*. Ibid., figs. 11—15, 1840.
PELTASTES STELLULATUS,	*Agassiz* et *Desor*. Cat. raison. des Échinides, Ann. Sc. Nat., 3e sér., tom. vi, p. 342, 1846.
— PUNCTATA,	*Agassiz* et *Desor*. Ibid.
— —	*Marcou*. Jura salinois, Mém. Soc. Géol. de France, 2e sér., t. iii, p. 140, 1848.
— PENTAGONIFERA,	*A. Gras*. Ours. foss. de l'Isère, p. 29, pl. i, figs. 11, 12, 1848.
SALENIA STELLULATA,	*Bronn*. Index Palæontologicus, p. 1008, 1849.
PELTASTES —	*D'Orbigny*. Prod. de Paléont. strat., t. ii, p. 89, 1850.
— PUNCTATA,	*D'Orbigny*. Ibid.
PELTASTES STELLULATA,	*Cotteau*. Catal. des Échinid. néocomiens, 1851.
— —	*Bronn*. Leth. Geognost., Kreidegeb., pl. xxix, fig. 5, 1852.
HYPOSALENIA —	*Desor*. Synops. des Échinid. foss., pl. xx, figs. 6—8, 1856.
— PUNCTATA,	*Desor*. Ibid.
PELTASTES STELLULATA,	*Pictet*. Traité de Paléont., 2e éd., t. iv, p. 248, 1857.
— PUNCTATA,	*Pictet*. Ibid.
— PENTAGONIFERA,	*Pictet*. Ibid.
— COURTAUDINA,	*Pictet*. Ibid.
— —	*Leymerie* et *Raulin*. Géol. de l'Yonne, Stat. géol. du dép. de l'Yonne, p. 420, 1858.
— STELLULATA,	*Leymerie* et *Raulin*. Ibid.
HYPOSALENIA —	*Cotteau*. Éch. foss. de l'Yonne, pl. 54, figs. 1—10, 1859.
PELTASTES STELLULATUS,	*Cotteau*. Paléontol. Française; Terrain Crétacé, pl. 1023, p. 100, 1862.

Diagnosis.—Test small, circular, convex above, flat below, poriferous zones straight, formed of oblique pairs, ambulacra straight, two rows of homogeneous mammillated granules, set closely together, fourteen in each row. Inter-ambulacra wide, two rows of tubercles, five in a row, unequal in size, large at the ambitus, and small near the base; apical disc very large, round, and depressed; sutures well marked with isolated points, and fine incisions; madreporic fissure small, distinct, and surrounded by an elevation of the plate.

Dimensions.—Height three tenths of an inch; transverse diameter half an inch.

Description.—The table of synonyms affords evidence how changes of form in certain parts of an Urchin lead to confusion in the identification of the species, and how impossible it is to define in a few words certain organisms among which the same structures vary much

in different individuals with age and the changing conditions of their existence. The apical disc of *Peltastes stellulatus*, Ag., is one of these; M. Cotteau remarks[1] that the ovarial plates are sometimes almost smooth, and present hardly any isolated points, as in *P. pentagoniferus*, Gras. In certain examples the number of these points augment sensibly, and the plates remaining perfectly smooth, the lines of the sutures are punctuated (*P. punctatus*, Ag.). Instead of isolated points, the sutures are often marked with lines or incisions which extend along the surface of the plates, and give to the apical disc a very remarkable parsley-leaved aspect (*P. stellulatus*, Ag.). Sometimes this character is exaggerated; the incisions become deep, and penetrate even into the interior of the plates, which unite at certain points, and produce a remarkable variety of disc seen in certain specimens collected from the calcaires à *Echinospatagus cordiformis* in the environs of Auxerre. In other examples, the plates independent of the points, more or less elongated which exist on the suture, are bordered by little flexuous bourrelets, which become attenuated as they approach the centre, as in *P. Courtaudinus*, Cot. These varieties, when studied separately, as they were discovered by different observers, were regarded as so many distinct types; but a careful comparison of the series has taught M. Cotteau that they are only so many varieties of the same species. The admirable figures given of these variations fully confirm my learned friend's conclusions on the unity of the species. The structure of the apical disc forms, therefore, an important character in the history of this species; and as the observations that have been made upon the differences noted on the ornamentation and sculpture of its elements are applicable to other forms of *Peltastes*, the careful study of this structure requires thoughtful notice in making a diagnosis of all supposed new forms of Salenidæ.

The ambulacral areas are quite straight (fig. 1 *b*), and between the two lateral rows of mammillated granules a zigzag line of microscopic granulets extends from the base to the summit (fig. 3 *b*).

The inter-ambulacral areas are wide and furnished with two rows of tubercles having crenulated bosses and imperforate mammillons; they are prominent, unequal in size, largest at the ambitus, and decrease towards the peristome; very large mammillated granules fill up the miliary zone and form very regular circlets around the primary tubercles. Between these granules in well-preserved specimens a number of microscopic granulets are seen closely arranged around their base.

The mouth-opening lies in a slight depression, and the peristome is divided into ten lobes by feeble incisions, with reflected borders (fig. 2).

The vent is transversely oval (fig. 3 *a*), and the periprocte has a slightly elevated and inflated border.

A variety of *Peltastes stellulatus*, Ag., figured in detail (Pl. XLI, fig. 1 *a*—*g*), was collected by the Rev. T. Wiltshire, F.G.S., from a greenish yellow band of the Red Chalk at Speeton, Yorkshire. The true position of this specimen was between the upper por-

[1] 'Paléontologie Française, terrain Crétacé,' t. vii, p. 102.

tion of the Gault and the base of the Upper Greensand; this stratum, about nine feet thick, contained small *Gryphææ* and *Terebratula semiglobosæ* with the *Peltastes;* and few fossils besides these. The apical disc (fig. 1 *b*) shows many punctuations in the line of the sutures; one entire ambulacra, magnified four times, is shown (fig. 1 *f*), and one entire inter-ambulacra, equally enlarged, in fig. 1 *e;* the structure of a single plate, magnified six times, in fig. 2 *g*, and the disc isolated, magnified four diameters, is shown in fig. 1 *d*. All these figures are drawn with the utmost care and truthfulness for comparison with other varieties of this species collected from the Sponge-Gravel of Farringdon and figured in Pl. XXXI, figs. 1—3. For an account of the Red Chalk of Speeton, in which this *Peltastes* was collected, the reader is referred to page 8 of this Monograph.

Affinities and Differences.—*P. stellulatus* resembles *P. Wrightii*, but, according to M. Cotteau, the species are quite distinct. M. Cotteau had a large series of the different varieties of *P. stellulatus* to compare with specimens of *P. Wrightii* from Farringdon, sent him by my lamented colleague, Professor Edward Forbes, and after a careful study of these fossils my learned friend observes, it is true, that *P. stellulatus* (var. *punctata*) closely resembles *P. Wrightii*, but nevertheless it is separated from it by its form being more inflated, its tubercles more numerous and less prominent, its apical disc more smooth, less thick, and marked only with some isolated points.[1]

Locality and Stratigraphical Position.—This species, which is very rare in England, was collected from the Lower Greensand at Farringdon, Berks, and the Red Chalk at Speeton, near Filey Bay, Yorkshire.

It is abundant, according to M. Cotteau, in France, in the Néocomien inf. et moyen at Saint-Sauveur, Fontenoy, Leugny, Auxerre, Bernouil, Tronchoy (Yonne); Marolles, Soulaines (Aube); Saint-Dizier (Haute-Marne); Germigney (Haute-Saône); Fontanil (Isère); Censeau, les Rousses (Jura), where it is abundant; and in Switzerland, according to Professor Desor, in the étage Valanginien or Néocomien inf. at La Chaux-de-Fonds, Sainte-Croix, Hauterive, Lauderon près Neuchâtel.

PELTASTES LARDYI, *Desor*. Pl. XXXI, fig. 4 *a, b, c, d.*

HYPOSALENIA LARDYI, *Desor*. Synops. des Échinides Fossiles, p. 148, 1856.
SALENIA ACUPICTA, *Desor*. Ibid., p. 152.
HYPOSALENIA LARDYI, *Pictet* et *Renevier*. Foss. du terr. Aptien de la Perte du Rhone, p. 161, 1858.
PELTASTES LARDYI, *Cotteau*. Paleontologie Française, terr. Cretace, t. vii, p. 106, pl. 1024, 1862.

Test circular, upper surface convex, under surface flat, sides inflated, poriferous zones straight, ambulacra narrow, straight, two rows of homogenous mammillated granules,

[1] 'Paléontologie Française, terrain Crétacé,' t. vii, p. 105.

eighteen in each. Inter-ambulacra wide, two rows of tubercles, five to six in each, largest at the ambitus. Apical disc large, circular, with undulating borders. Mouth-opening circular, peristome decagonal, vent transversely oval.

Dimensions.—Height four tenths of an inch; transverse diameter eight tenths of an inch.

Description.—This Salenia, belonging to the British Museum, is a very rare form, and was referred by my late friend Dr. Woodward to *P. Lardyi*. The test is circular with inflated sides; the upper surface is convex and elevated, and the base is flat. The poriferous zones are straight, formed of oval pores arranged in oblique pairs; separated a small granule, and unigeminal, throughout, except at the base, where they are a little crowded.

The ambulacral areas are straight, with two rows of marginal homogenous, mammillated, granules, eighteen in a row (fig. 4 *c*, *d*); between the rows there are a double series of microscope granulets filling in the spaces.

The inter-ambulacral areas are large, with two rows of tubercles, five to six in each (fig. 4 *d*), largest at the ambitus, diminishing above towards the disc, and below towards the peristome; a double row of large mammillated granules extends down the middle of the area, and forms circlets around the tubercles; a large mammillated tubercle occupies the outer angle of each plate near its union with the poriferous zones (fig. 4 *c*, *d*). Around the base of these granules a number of small granulets are freely distributed; the surface of the test has therefore a highly ornamented appearance.

The apical disc is large and undulated at the border; in our specimen (fig. 4) the sutures are much filled in, and the typical character of the species is thereby obscured. In the beautiful specimens from the Aptien of Auxerre the sutures are sharply engraved with isolated points and lines of incision, so as to impart a parsley-leaved character to all the elements of the disc. The vent is moderately wide and transversely oval, and the rim of the periprocte is a little elevated.

The mouth-opening lies in a slight depression, it is about half as wide as the diameter of the test. The peristome is decagonal, and marked by feeble incisions; of the ten lobes those over the ambulacra are the largest.

Affinities and Differences.—In its form and general characters *P. Lardyi* approaches *P. stellulatus;* it is, however, a larger Urchin, with its upper surface more convex and inflated, sometimes it even assumes a sub-conical shape; the marginal rows of mammillated granules on the ambulacra are more numerous, and separated from each other by a double series of microscopic granulets; the apical disc is likewise thicker and more prominent.

Locality and Stratigraphical Position.—Collected from the Sponge-gravel of the Lower Greensand, near Farringdon, where it was associated with *P. Wrightii*. It is a very rare form in the English Neocomian strata. The fossil figured belongs to the British Museum, and is the only English specimen I know.

B. *Species from the Upper Greensand.*

PELTASTES CLATHRATUS, *Agassiz.* Pl. XXXII, fig. 1 *a—f*, 2, 3, 4.

Parkinson's Organic Remains, vol. iii, pl. i, fig. 13, 1811.
SALENIA CLATHRATA, *Agass.* MSS. Morris's Catalogue of British Fossils, p. 58, 1843.
— STELLULATA, *Id.* Ibid. Ibid.
— UMBRELLA, *Id.* Ibid. Ibid.
— ORNATA, *Id.* Ibid. Ibid.
— CLATHRATA, *Bronn.* Index Palæontologicus, p. 1007, 1849.
— UMBRELLA, *Id.* Ibid., p. 1008.
— CLATHRATA, *Forbes.* In Morris's Catalogue of British Fossils, 2nd ed., p. 89, 1854.
— STELLULATA, *Id.* Ibid. Ibid.
— UMBRELLA, *Id.* Ibid. Ibid.
— CLATHRATA, *Woodward.* Mem. of Geol. Survey, App. to Decade V, p. 6, 1856,
— — *Desor.* Synopsis des Échinides Fossiles, p. 151, 1856.
PELTASTES CLATHRATUS, *Cotteau.* Paléontologie Française, terr. Cretacé, tome vii, p. 119, pl. 1028, fig. 8—18, 1862.

Diagnosis.—Test subglobose very convex above, poriferous zones straight, ambulacra narrow, straight, with two rows of mammillated granules. Inter-ambulacra wide, three pairs of prominent tubercles, miliary zone narrow. Apical disc very large, covering nearly the entire upper surface, its outline very deeply indented between the ovarial and ocular plates, which are smooth, and deeply notched at the sutures; those connecting the centres of the plates forming a distinct pentagon, each of the ovarial pores is the centre of five radiating grooves with angular depressions between them.

Dimensions.—Height nine twentieths of an inch; six tenths of an inch.

Description.—This Salenia is a very common species in the Upper Greensand of Wiltshire, where it is often found in a fine state of preservation. The test in general is small and subglobose, although depressed varieties sometimes occur. It is collected likewise from the Grey Chalk near Folkestone, from whence the largest individuals have been obtained. In the subglobose forms the upper surface is convex and inflated, and the under surface is flat, with rounded sides (Pl. XXXII, fig. 1 *a*). The ambulacral areas are narrow and very slightly flexed; two rows of small mammillated tubercles, fourteen to sixteen in each, set closely together, are placed on the sides of the area (fig. 1 *d*), and a line of microscopic granules occupies the centre, and a few are scattered between the tubercles (fig. 1 *e*). The poriferous zones are slightly flexed (fig. 1 *d*), and the holes lie in oblique pairs (fig. 1 *e*); the septum separating each pair has a prominent elevation; and there are eight pairs of holes opposite the larger plates.

The inter-ambulacral areas are wide, and the plates in the columns unequal in size;

there are four or five tubercles in each series, and of these the two uppermost only attain a considerable development (fig. 1 *b*, and fig. 1 *d*, and fig. 3). The others are much smaller, and diminish in size as they approach the peristome (fig. 1 *c* and fig. 1 *d*); the margin of each plate is surrounded by a series of small mammillated granules (fig. 1 *e*, and fig. 3), which form a circle around the tubercles, and in the upper part of the area between the larger granules a number of smaller granulets are placed between them (fig. 1 *d*), thus completing the ornamentation of the miliary zone.

The base of this urchin is flat, and the mouth-opening small (fig. 1 *c*); the peristome is divided into ten nearly equal lobes, by feeble incisions (fig. 1 *f* and fig. 1 *c*).

The apical disc is very large, and occupies all the upper surface of the test (fig. 1 *b*, fig. 3). Its ovarial plates are deeply cut, with numerous incisions, which are much better defined by figures than words; faithful portraits of these most complicated impressions my friend Mr. Bone has given in fig. 1 *b*, fig. 2, fig. 3, and fig. 4. These incisions are large and deep, and extend through the thickness of the plates; three deep incisions mark the line of suture between the ocular and ovarial plates (fig. 2); the two antero-lateral ovarials have another series of impressions of a like character before the vent and behind the oviductal opening. The oviductal holes are large; the two anterior are placed forward on their respective plates; the three posterior lie near the inner borders of the genital plates and opposite the angles of the periprocte. The ocular plates are heart-shaped, and the orbit occupies a depression at the summit of the ambulacra, near the extreme border of the plates. The vent is large and transversely oblong, sometimes even becoming angular (fig. 1 *b*). The periprocte is elevated, and its funnel-shaped extremity encircled by a bourrelet directed backwards (fig. 3). Most specimens show this elevation of the vent, but in many varieties it is not so conspicuous as in the type specimen figured in fig. 3, where the test is magnified twice. The spines are long and needle-shaped (Pl. XLII, fig. 4); above the milled ring is a broad band of longitudinal lines, and the rest of the stem is covered with very fine longitudinal microscopic lines. For further details on the spines of this and other species, see description of Pl. XLII.

Affinities and Differences.—*Peltastes clathratus* is readily distinguished from its congeners by its subglobose test, the great size of its apical disc, and the number, width, and depth of the numerous incisions that divide its surface; its flat base and small mouth opening, with its rounded sides, present an ensemble of characters which well characterise the species and separate it from all the others.

Locality and Stratigraphical Position.—This species was in former years very common in the Upper Greensand near Warminster. Small examples were most abundant, and large specimens were rare. The largest tests are collected from the Grey Chalk near Folkstone; my kind friend the Rev. T. Wiltshire has obtained several large examples from this stratum, and several of these have their spines *in situ* on the test.

M. Cotteau gives as the French localities of this species, where it is very rare, l'Étage Cenomanien, Le Havre, Seine-Inférieure, La Perrière, Orne, Craie à Scaphites.

PELTASTES UMBRELLA, *Agassiz*, MSS. Pl. XXXIV, fig. 1 *a*—*d*, fig. 2 and 3.

SALENIA UMBRELLA, *Agass.* MSS. Morris's Catalogue of British Fossils, p. 58, 1843.
— — *Id.* Forbes, in Morris's Catal. of British Fossils, p. 89, 1854.
— CLATHRATA, *Id.* Woodward (pars), Mem. of Geol. Surv., App. to Decade V, 1856.

Diagnosis.—Body subglobose, convex above; apical disc large, covering the upper surface, its outline deeply indented between the ovarial and ocular plates, sutural grooves deeply and sharply cut, those connecting the centres of the plates forming a distinct pentagon. Each oviductal hole forms a centre, from which five grooves radiate, having angular pits between them; sur-anal plate marked with an inverted triangle formed by horizontal and inclined incisions. Ambulacra wide; two rows of mammillated tubercles crowded with granules around the base; interambulacra with four large tubercles in the upper part, and all the others small, diminishing towards the peristome; base flat, mouth-opening small.

Dimensions.—Height, one quarter of an inch; latitude half an inch.

Description.—I have figured the type specimen of this form belonging to the British Museum, as it is the species Prof. Agassiz gave this manuscript name to many years ago, when he examined the Cretaceous Urchins in the National Collection. Whether *P. umbrella* is specifically distinct from *Peltastes clathratus* I am not in a position to decide. The apical disc is certainly much more angularly incised, and more sharply defined than in *P. clathratus;* and placing two well marked specimens of these type forms in contrast, the decision would be in the affirmative; but then we have the evidence of M. Cotteau, who informs us that the incisions and impressions on the disc alone are not to be relied on as specific characters, as one form glides into another by a series of intermediate gradations, which connect together forms that appeared when isolated to be very distinct from one another.

The ambulacral areas are nearly straight, and have two marginal rows of small mammillated tubercles, fourteen in each. The mesial space between the rows and tubercles is filled with microscopic granules (fig. 1 *c*). The poriferous zones are conspicuous, and the pores placed in oblique pairs. The inter-ambulacral areas are wide, and the plates in the columns unequally developed, those above the ambitus are the widest, and support large tubercles; from the ambitus to the peristome they gradually become smaller, and their respective tubercles diminish in the same proportion (fig. 1 *b*, fig. 1 *c*, and fig. 2).

The apical disc is large, and its circumference much indented between the margin of the ocular and ovarial plates (fig. 1 *a*, and fig. 3), presenting two beautiful varieties of this remarkable structure. The sur-anal plate situated before the periprocte is marked with incisions that form a triangle; each oviductal hole of the two antero-lateral ovarial plates forms a centre, from which five incisions radiate, and from each oviductal hole in the other three ovarial plates four incisions radiate outwards, having angular pits between

them. The vent is raised on an eminence which is directed backwards. The anal opening is transversely oval, and the periprocte forms a thickened bourrelet, which is oblong in the variety fig. 1 *a* and angular in fig. 3. In both figures the apical disc is magnified four diameters.

The base of the test is flat, and the mouth opening small, about one third the diameter of the test. The specimens figured in figs. 2 and 3 have been kindly communicated by W. Cunnington, Esq., F.G.S., as remarkably well marked forms of this species.

Affinities and Differences.—The test of *P. umbrella* closely resembles that of *P. clathratus*, the difference chiefly residing in the form and structure of the apical disc, which can be much better understood by a comparison of the figures in Pl. XXXII, fig. 2, and Pl. XXXIV, fig. 1 *a*, fig. 1 *b*, fig. 1 *d*, and fig. 3, and to which we must beg to refer the reader.

Locality and Stratigraphical Position.—The type specimen was collected from the Upper Greensand near Warminster, associated with *Peltastes clathratus* in the same stratum.

PELTASTES BUNBURYI, *Forbes*, sp. Pl. XXXIX, fig. 2 *a*—*i*.

SALENIA BUNBURYI, *Forbes*. In Morris's Catalogue of British Fossils, p. 89, 1854.
— — *Woodward*. Mem. Geol. Surv., App. to Decade V, p. 6, 1856.

Diagnosis.—Test subglobose, much elevated, sides tumid, base wide and flat; oral aperture depressed; apical disc large, very deeply indented at the border, between the ocular and ovarial plates; a series of ten elliptical ridges with central depressions forming an ornamented pentagon on the disc; sur-anal plate with two pairs of oblique elliptical ridges. Vent large, diamond-shaped, excentral, looking obliquely backwards, with a thickened periprocte. Ambulacra narrow, slightly flexed, with small remote marginal tubercles, separated by a prominent ridge of microscopic granules. Inter-ambulacra wide; three prominent tubercles at the ambitus, and four smaller near the base; upper surface covered with scattered granules.

Dimensions.—Height, half an inch; transverse diameter, thirteen twentieths.

Description.—The original and unique specimen of this *Salenia* was presented to the Museum of the Royal School of Mines by E. H. Bunbury, Esq., M.P. My late lamented colleague Professor Edward Forbes named this Urchin, without leaving any notes of its specific characters. A brief diagnosis of these were given by my late friend Dr. Woodward in his appendix to the fifth Decade of the Organic Remains in the Memoirs of the Geological Survey. It is now figured for the first time.

The test is subglobose and much elevated (fig. 2 *a*—*d*), inclining to a conical form. The ambulacral areas are narrow, and slightly flexed with two rows of small remote marginal tubercles, sixteen or seventeen in each row. These are separated by a median ridge formed of microscopic granules, which fill up all the space unoccupied by the tubercles.

The poriferous zones are narrow, the pores small and placed in oblique pairs, of which there are forty in each zone. The septa between the pores are capped by a prominent granule.

The inter-ambulacral areas are wide, and the plates in the columns of unequal size. There are three large tubercles in each area; of these one is very large, and two moderately so; the five others diminish gradually towards the peristome; the upper surface is destitute of tubercles, and this vacant space is covered with small, various sized, sparsely scattered, mammillated tubercles; a series of these encircle the areolas of the primary tubercles. Fig. 2 *f* represents an inter-ambulacral area, magnified four diameters, showing the great disparity existing between the volume of the different tubercles developed therein. The miliary zone is likewise ornamented with similar bodies. Fig. 2 *h* displays these parts, magnified six times, in a single plate, and fig. 2 *i* a tubercle seen in profile.

The base is wide and flat, and highly ornamented with the small close-set tubercles of the inter-ambulacral areas. The oral aperture, one third the diameter of the test, lies in a depression (fig. 2 *c*). The peristome is divided into ten lobes by feeble incisions.

The apical disc occupies a large portion of the upper surface; its border is exceedingly sinuous, and deeply incised at the marginal boundary line between the ocular and ovarial plates; from each oviductal hole two pairs of elliptical-shaped incisions proceed, and right and left to join those proceeding from the adjoining oviduct; and these form the sides of the pentagon which extends around the disc. The sur-anal plate is marked by two pairs of elliptical incisions, which join those from the anterior ocular, and thus form a diamond-shaped impression before the vent (fig. 2 *c*). The ovarial plates terminate in three-lobed cardiform expansions, and from each side of the orbits similar heart-shaped trilobate bodies stretch obliquely outwards. The disc of this species forms a most complicated structure, of which words fail to give any adequate idea. Fortunately, my friend Mr. Bones' admirable figures supply the eye with the fine symmetrical proportions of this intricate bit of anatomy. Consult fig. 2 *a*, *b*, *d*, *e*, for all details.

The vent is large and looks obliquely backwards; it is of a diamond shape, with a thick prominent periprocte; at the three posterior angles of this bourrelet the single and postero-lateral oviducts open, the two antero-laterals are placed much in advance on the lateral boundary of the sur-anal.

Affinities and Differences.—The sculpture of the apical disc and the deep incisions through the same reminds us of some forms of *Peltastes clathratus;* the margin, however, is more deeply indented, and the style of ornamentation on the same is different; the marginal tubercles on the ambulacra are smaller and more remote, and divided by a prominent granulated ridge; the structure of the inter-ambulacra exhibits a considerable difference, and the pores in the zones are smaller and more numerous.

Locality and Stratigraphical Position.—This rare Salenia was collected from the Lower Chalk, Mildenhall, near Bury St. Edmunds. The original and unique specimen is in the Museum of the Royal School of Mines.

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MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART FIFTH.

ON THE SALENIDÆ.

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PELTASTES WILTSHIREI, *Wright*, nov. sp. Pl. XL, fig. 1 *a—h*.

Diagnosis.—Test subglobose, elevated at the upper surface, flat at the base; ambulacra narrow, straight, two rows of marginal mammillated granules; poriferous zones narrow, and slightly flexed; inter-ambulacra wide, two rows of large tubercles, five in each; apical disc very broad, margin deeply cut out; ovarial plates largely incised; vent elevated; periprocte prominent, projecting outwards and backwards.

Dimensions.—Altitude, six tenths of an inch; latitude, eight tenths of an inch.

Description.—We owe the discovery of this beautiful *Peltastes* to the long, careful, and patient study of my excellent friend, the Rev. T. Wiltshire, F.G.S., on the red chalk of England, to whose valuable collection it belongs. The test is subglobose, much elevated on the upper surface, and covered with a very large apical disc; the base is flat, and the sides are tumid. The ambulacral areas, very narrow and straight, are occupied by two rows of small oblong mammillated marginal granules, about nineteen in each row, separated by a narrow band of fine, close-set granulations, which extends from the base to the summit of the area; the poriferous zones are narrow and slightly flexed, and the small pores are arranged in oblique pairs, of which there are thirty-eight in each zone. Fig. 1 *f* exhibits one entire ambulacrum, with its poriferous zones, magnified four diameters.

The inter-ambulacral areas are wide and largely developed (fig. 1 *a*, *d*, *e*); the ovarial and ocular plates of the apical disc cover up much of the upper portion (fig. 1 *b*, *d*, *e*); there are ten primary tubercles in each area, of which four are very large, two small, and four smaller; they are all surrounded by wide areolas (fig. 1 *d*, *e*), and around their margins a few large granules are sparsely disposed, about five around the largest plates, three at the central, and two at the zonal side of the plate, as shown in fig. 1 *h*. The base is flat (fig. 1 *c*), about two fifths the diameter of the disc, the mouth-opening is nearly one half the diameter of the test, and the peristome is divided into ten nearly equal lobes by deep incisions; the numerous small tubercles at the base of the areas, and the larger size of the marginal ambulacral granules, impart to this region of the test a highly ornamented appearance (fig. 1 *c*).

The apical disc (fig. 1 *b* and *g*) is a large and complicated structure; the suranal plate lies in front of the vent, and is notched with sections of four elliptical impressions; the ovarial plates are large and cut in a like manner into similar patterns, the two adjoining plates contributing each one half of the ellipse, so that the sculptured pattern on the entire disc is made up of separate pieces like mosaic; the oviductal holes are in the middle of the plates and on the right antero-lateral; the madreporiform tubercle appears like a laceration on the inner side of the oviductal hole—this has unfortunately escaped the eye of our artist, as it looks more like a portion of decayed plate than a veritable natural structure. The ocular plates are likewise large, and have five or six notches round their border, which in like manner join similar notches on the ovarial plates and complete the elliptical pattern

of the sculpture of the disc; the outer border of each ocular plate forms a crescent around the summit of the ambulacra, and the terminal portions of the ovarial plates form an elegant five-leafed petal extending down the middle of the inter-ambulacra; the outer margin of the disc is therefore very deeply incised between the ovarial and ocular plates, and produces a structure which will be better understood by an examination of fig. 1 *g*, magnified four diameters, than by any verbal description. The vent is large and the periprocte bluntly diagonal, angular at the sides, and less convex before than behind (fig. 1 *g*); when viewed in profile, as in fig. 1 *a* and *d*, the apical disc is conspicuously prominent, and the elevated periprocte is seen to be very excentral and projected far backwards.

Affinities and Differences.—This beautiful species in its general characters resembles *Salenia Austeni*, Forbes; but a careful comparison of the tests of both species discloses important differences; the ambulacra in *P. Wiltshirei* are narrower, with only two rows of oblong marginal granules throughout, whilst *S. Austeni* has four rows in its wider ambulacra. The inter-ambulacral areas in *P. Wiltshirei* are wider, and the primary tubercles therein fewer and larger than in *S. Austeni*. The apical disc of *P. Wiltshirei* is much larger; the marginal incisions are deeper, the lines of sculpture wider, and the periprocte is in the axis of the suranal plate.

This species resembles *P. Bunburyi*, Forb., in the general structure of the test, and of the apical disc; the inter-ambulacral areas in *P. Wiltshirei* are wider, the tubercles are larger and more regular, the apical disc covers a wider surface of the test than in *P. Bunburyi*, and is deeply sculptured after a different pattern, both around the margin and along the sutures of the plates.

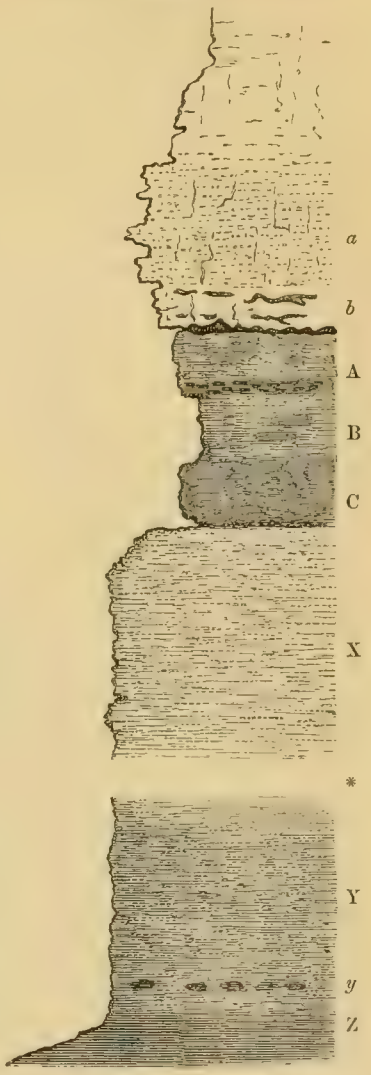
Locality and Stratigraphical Position.—This *Peltastes* is a very rare Urchin in the Red Chalk of Hunstanton Cliff, Norfolk, where it was found by the Rev. T. Wiltshire, F.G.S., who has contributed a valuable paper on this stratum to the 'Quarterly Journal of the Geological Society,'[1] and from which I have made the following quotations, as the true position of the Red Chalk is well defined in that communication. I am indebted to the kindness of the Council of the Geological Society for the use of the annexed woodcut illustrating the stratigraphy of this locality.

Hunstanton Cliff "is marked by three parallel coloured bands, slightly inclined, and cropping out in succession on the surface soil, of which bands the uppermost is white, the next bright red, and the lowest yellow, each division being sharply defined, without any intermingling of tints at the line of contact. . . . The highest stratum, the white, consists of a hard calcareous substance, compact in texture, and much shattered and fissured, originally deposited in such a manner that its materials were arranged in definite layers, two of which (*a b*), those forming the base, are represented in the annexed section drawn to scale. The first of these (*a*), in thickness about 2 feet 6 inches, is noticeable for the presence of an enormous quantity of fragments of *Inocerami* dispersed throughout its

[1] 'Quart. Journ. Geol. Soc.,' vol. xxv, p. 185, 1869.

whole extent, and which under the influence of weathering impart to this portion of the cliff a jagged and rough appearance. Its characteristic fossils are spines of *Cidaris vesiculosa*, *Holaster planus*, *Vermicularia umbonata*, *Terebratulina gracilis*, *Terebratula semiglobosa*, and *Plicatula inflata*. The band *b*, in thickness about 1 foot 2 inches, is conspicuous for a meandering and many-branched Sponge (*Syphonia paradoxica*), specimens of which are visible in the cliff only in short lengths, but on the fallen blocks washed by the sea are seen to extend continuously and horizontally over many square feet of surface. The underside of *b* departs from the general arrangement in the other courses; for its base, instead of forming a flat or approximately flat floor, is broken up into a series of irregularly rounded ridges and hollows, which undulate perpendicularly within the limits of a few inches, and are represented in the section. The fossils from this bed (*b*) are not so many (numerically speaking) as those in *a*. The chief forms are *Siphonia paradoxica*, *Terebratula biplicata*, *Terebratula semiglobosa*, var. *undata*, *Kingena lima*, *Avicula gryphæoides*, and *Inoceramus latus*.

Section of Hunstanton Cliff.



"Next in succession, in descending order, is the red stratum, locally called the 'Red Chalk,' marked by an abundance of organic remains, some of which, as *Bourgueticrinus rugosus* and *Terebratula capillata*, are, in England, special to this deposit. Lithologically it is unlike the beds above it, from the fact of its abounding in great numbers of rolled and subangular pebbles of quartz, slate, &c., which for the most part are of small size and insignificant, though occasionally assuming larger dimensions. In appearance it is divisible into three almost equal portions, of which the first (A) has towards its base a large quantity of fragments of *Inocerami*, the second and thickest division (B) is rich in *Belemnites*, and the third and lowest (C) yields many *Terebratulæ*. The bands A and B are exceedingly hard and stony, and sufficiently tabular in character to have offered a plane of resistance to former upheaving forces, and to have afforded great support to the overlying white beds; thus, although the whole cliff was evidently, in ancient geological times, much disturbed, the perpendicular fissures which rise out of the yellow bands

* A thickness of upwards of 30 feet is here omitted for convenience.

(Y, X) cease just before reaching the layer B, affect the red beds to the right and left of the points of application, and then start upwards through the white stratum in new positions and in greater number. The colouring matter in A is less equally distributed than in B and C, and seems to have been accumulated as an envelope around irregular spheroidal masses; in B the tint is of a lighter, and in C of a darker shade than in the highest division. The middle bed (B) is in substance the hardest and most homogeneous of the three; the last (C) is the least compact. Viewed in the cliff, A wears a mottled aspect, B a nodular facies, and C a plain surface. Towards the base of the bottom bed (C) the hard limestone character of the Red Chalk is lost, and the stratum degenerates into a somewhat sandy incoherent mass, hardly differing from the underlying yellow division, except in colour. On account of the less compact nature of the last of the three red beds, fossils are more easily procured from it, have their surfaces in better condition, and are more readily seen when of small size. Resting on the top of A and filling the undulations on the under side of the lowest white bed (*b*) is a bright red argillaceous substance, very friable, without sand, apparently destitute of organic remains, and never exceeding two or three inches in thickness.

"The fossils in the three red beds are for the most part similar, and suggest the inference that all three bands may be considered as forming a single division, and composing one geological stratum. In the case where certain fossils have been seen only in the lowest part, their absence elsewhere may be accounted for on the ground that the upper bed (A) is less numerically abundant in organic remains than are those below, and that the middle bed (B) is so exceedingly hard and compact as to diminish the chance of discovering fossils. *Avicula gryphæoides* and *Spongia paradoxica* would seem, however, to be special to the upper part of A, the highest of the three red beds. The dip of these beds in the cliff is about 2° to the north; sections inland, taken at right angles, give the same number of degrees to the east.

"Underlying the Red Chalk is a coarse sandy deposit (X, Y of the Section) termed in the district 'Carstone,' of a yellow tint, loose in composition, and full of small pebbles, which are subangular and polished. The upper part (X), for about 8 feet, consists of much sand, and is succeeded by a dark brown stratum (Y), in which, at the beginning, the pebbles are of larger size, and in which, afterwards, the sandy particles are so loosely held together as to present a strong contrast to the massive nature of the white and red beds above. Covered by the Carstone and adjoining it is a bed of clay marked Z in the section.

"Throughout the space of more than thirty feet below the base of the Red Chalk no fossils have been hitherto found at Hunstanton in the Carstone; but beyond that distance, and just above the clay (Z), there is a line of nodules (*y*), in which are numerous specimens of *Ammonites Deshayesi*, and occasionally of *A. Cornuelianus;* close to these nodules are others of ironstone, very similar to the masses found in the Lower Greensand of Blackgang and Shanklin, in the Isle of Wight, containing casts of fossils.

"From this part of the Carstone I have obtained *Perna Mulleti*, *Ancyloceras gigas*, *Pleurotomaria gigantea*—fossils which, viewed in connection with the presence of *Ammonites Deshayesi*, &c., correlate the portion of the Carstone immediately above the clay (z) with the base of the English Lower Greensand.

"By a reference to the section it will be seen that the Hunstanton Red Chalk is, in position, lower than the Chalk-marl (*a*), and higher than the Lower Greensand (x, y); the fossils also, it will be observed, recorded in the list as common to the bed, present a mixture of what are generally considered Lower Chalk, Upper Greensand, and Gault forms. The mingling together of these species, no less than the peculiar aspect of the stratum, has long caused the Red Chalk to be a fertile field for discussion in reference to its proper position in the geological scale, various writers offering various opinions, Mr. C. B. Rose[1] inclining to its being the equivalent of the Gault, Mr. H. Seeley[2] to its being Upper Greensand, and Mr. Judd[3] to its combining both formations. If, however, the very fine section of the Gault at Folkstone (where the succession of the beds and their fossils can be examined *in situ*) be taken as typical of the English Gault, then it will become evident that the 'Red Chalk' is the representative of the upper division of that formation."

Genus—Goniophorus, *Agassiz*, 1838.

Goniophorus, *Desor.* Goniophorus, *Cotteau.*

Test small, circular, elevated above, and flat beneath. Interambulacral areas wide, two rows of large tubercles with well-developed areolæ, crenulated bosses and imperforate mammelons; pores small, simple, unigeminal. Ambulacral areas very narrow, and having the poriferous zones slightly undulated.

Mouth-opening small, peristome decagonal, with nearly equal sized oral lobes.

Apical disc smooth, prominent, regularly pentagonal, and moderately large, composed of five ovarial and five ocular plates, and one suranal placed before the vent, which is excentral, in the axis of the body, and placed a little backwards, as in the genus *Peltastes*. The disc is destitute of sutural impressions so characteristic of many Salenidæ, and is ornamented with prominent carinæ, which assume regular geometrical figures, altogether independent of the form of the ovarial plates or their connecting sutures; in fact, it is

[1] "On the Geology of West Norfolk," 'Phil. Mag.,' 1835, vol. vii, p. 180.

[2] "Notice of Opinions on the Stratigraphical Position of the Red Limestone," 'Ann. Mag. Nat. Hist.,' 1861, vol. vii, p. 240.

[3] "Strata which form the base of the Lincolnshire Wolds," 'Quart. Journ. Geol. Soc.,' vol. xxii, p. 249, 1867.

the carinated structure, superadded to the surface of the disc, which forms one of the most distinctive characters of this group.

The genus *Goniophorus* resembles *Peltastes* in the arrangement of the elements of the apical disc and the relative position of the periprocte to the axis of the body. It is distinguished from it, however, in the absence of sutural impressions, and the presence of prominent ribs, that divide the surface of the pentagonal disc into a number of triangular areas (Pl. XXXVI, figs. 1 and 2).

M. Cotteau[1] has added another character, which he considers of more importance than the preceding; and observes, "The structure of the ambulacra presents a difference much more important, and the existence of poriferous impressions at the base of some of its granules form a type certainly exceptional, which ought to have a place apart in the Family Salenid.e. This character has not hitherto been noticed in any other Echinid."

Goniophorus lunulatus, *Agassiz*, 1838. Pl. XXXVI, fig. 1 *a—d*, fig. 2 *a—d*.

Goniophorus	lunulatus,	*Agassiz.* Monogr. des Salénies, p. 30, pl. v, figs. 17—24, 1838.
—	apiculatus,	*Agassiz.* Ibid., p. 32, pl. v, figs. 25—32, 1838.
—	—	*Agassiz.* Catal. Ectyp. Foss., p. ii, 1840.
—	favosus,	*Agassiz*, MS. Morris's Catal. of British Fossils, p. 52, 1843.
—	lunulatus,	*Morris.* Catalogue of British Fossils, p. 52, 1843.
—	—	*Agassiz* et *Desor.* Catal. raison. des Échinides, Ann. des Sc. Nat., 3e série, t. vi, p. 343, 1846.
—	apiculatus,	*Agassiz* et *Desor.* Ibid.
—	—	*Bronn.* Index Palæontol., p. 548, 1849.
—	favosus,	*Bronn.* Ibid.
—	lunulatus,	*Bronn.* Ibid.
—	—	*D'Orbigny.* Prod. de Pal. strat., t. ii, p. 179, 1850.
—	apiculatus,	*D'Orbigny.* Ibid.
—	favosus,	*D'Archiac.* Hist. des Progr. de la Géol., t. iv, p. 51, 1851.
—	lunulatus,	*Bronn.* Lethæa geogn., t. ii, p. 184, pl. xxix, fig. 6, 1852.
Salenia	lunulata,	*Morris.* Catal. of Brit. Foss., 2 ed., p. 89, 1854.
Goniophorus	apiculatus,	*Desor.* Synopsis des Échinides Foss., p. 14, pl. xx, fig. 12, 1856.
—	lunulatus,	*Pictet.* Traité de Paléontol., t. iv, p. 248, 1857.
—	apiculatus,	*Pictet.* Ibid., pl. xcvii, fig. 3, 1857.
—	lunulatus,	*Cotteau.* Paléontol. Française, t. vii, pl. 1029, figs. 8—19, 1864.

[1] 'Paléontologie Française,' t. vii, p. 126, Terrain crétacé.

Diagnosis.—Test small, globular, upper surface elevated, summit depressed, base flat, sides rounded; ambulacra narrow, slightly flexed, filled with two rows of granules; inter-ambulacra wide, two rows, six in each, of well-developed tubercles; apical disc small, angular, and pentagonal; diagonal ridges of shell marking the surface of the plates; base narrow, concave; mouth-opening small, peristome decagonal with equal lobes.

Dimensions.—A. The largest specimen, fig. 1 *a*, altitude half an inch; latitude six tenths of an inch.

B. Altitude, three lines; latitude, five lines.

C. Altitude, two and a half lines; latitude, three and a half lines.

Description.—This beautiful little Urchin, the sole representative of the genus *Goniophorus*, was at one time not uncommon in the Upper Greensand, near Warminster, and it is curious that no second species of the remarkable group to which it belongs has up to the present time been discovered; the two other forms which appear in the table of synonyms (*G. apiculatus*, *G. favosus*) being only usual varieties of the original type, so beautifully and accurately figured by M. Nicolet in Professor Agassiz's 'Monographies d'Échinodermes,' where it was for the first time described.

The test is small and nearly globular, the upper surface much elevated, the summit a little depressed, the sides inflated, and the base narrow and flat. The ambulacral areas are very contracted, and slightly flexed (fig. 2 *b*), the two rows of granules are set so closely together that they alternate on the area; the poriferous zones are nearly as wide as the ambulacra, the pores are oblique, and the pairs remote from each other, twenty-four in the zone. The inter-ambulacral areas are well developed (fig. 2 *a*); in the specimen, fig. 1 *a*, there are six primary tubercles in each row, the four above the ambitus are much larger than those on the lower part of the area, and the areola of each tubercle is surrounded by a complete circle of small mammillated tubercles (fig. 1 *a*, *d*, and fig. 2 *a*, *c*); the miliary zone separating the two series is narrow and zig-zag, and only a little enlarged at the upper surface (fig. 1 *d*, fig. 2 *a*).

The base is narrow and concave, and the small mouth-opening, one third the diameter of the test, lies in a central depression; the peristome is divided by feeble incisions into ten equal-sized lobes (fig. 1 *c*).

The apical disc (fig. 1 *b*, *d*) forms a regular pentagon, ornamented with prominent ridges; an external carina bounds the outline of the disc, an oval carina encircles the vent, and two others extend from the anterior part of the periprocte to the two anterior sides of the discal pentagon (fig. 2 *d*), and two others unite these with the sides of the vent (fig. 1 *b*); these ridges of ornamentation have nothing whatever to do with the sutures of the disc, which are very delicate, and only seen in some rare specimens; these sutures in *Goniophorus* are destitute of the incisions, punctuations, and impressions which form so remarkable a feature in the test of *Peltastes*.

The suranal plate lies before the periprocte, having the two anterior carinæ passing from the periprocte to the anterior border extended over its surface; the two antero-lateral

ovarials have a rhomboidal figure, the postero-laterals an irregular shape, occasioned by the lateral extension of the vent, and the single plate is still longer and narrower by reason of the space occupied by the same aperture; the oviductal holes occupy the centres of the sides of the pentagon near the point touched by the diagonal carinæ that cross the ovarial plates. The ocular plates form small triangular bodies, the apices of which touch the summits of the ambulacra (fig. 2 *b*); in neither of the fine specimens from Mr. Cunningham's collection, nor in those from the School of Mines, which were selected as the best extant for figuring, could the sutures of the ovarial and ocular plates be seen. I have only discovered them now, April, 1871, long after the drawings were executed, in an otherwise indifferent specimen of my own, collected many years ago, and I have been able therefrom to trace out these sutural lines satisfactorily, and complete my description of the apical disc of this most curious and beautiful *Salenia*. The vent is transversely oblong, inclining to an angular figure, and surrounded by a ridge of the test, which well defines its boundary, and forms a prominent periprocte at the same time. The carinæ of the disc cross the sutures of the plates in all directions, especially those anterior to the periprocte, and convert its surface into a series of seven triangles when all the ridges are preserved entire.

Affinities and Differences.—This Urchin is so entirely different from other Salenidæ in the structure of its apical disc that it forms a type quite distinct from all the others; the calcareous processes or carinæ on the surface of the ovarial and ocular plates have nothing whatever to do with the sutural lines which unite the elements of the discal apparatus, whereas in *Peltastes* and *Salenia* the figures on the disc are always developed in the line of the sutures.

Locality and Stratigraphical Position.—This Urchin has been collected from the Upper Greensand near Warminster; on the Continent it is a very rare fossil. The original specimen was found in the Étage Cénomanien, at Cap la Hève, near Havre, Seine Inférieure; others from the same stratum at Vaches Noires, Calvados, and Vimoutiers, Orne; in all these localities it is reported as being very rare.

History.—First described and figured by Professor Agassiz in his 'Monographie sur les Salénies.' In this work he described two forms as distinct species, *G. lunulatus* and *G. apiculatus*, which I consider as varieties only of the same Urchin. Professor Agassiz afterwards gave the MS. name *G. favosus* to a form of this group which he saw in the collection of Mr. Bunbury, of London, and the name found its way into Professor Morris's 'Catalogue of British Fossils,' 1st Edition; this variety exhibits only a slight deviation from the type form, so that the singular genus *Goniophorus* is at present represented by the beautiful little Urchin now under consideration. Seeing that so many examples of Salenidæ have been collected from the Upper Greensand of England, and the Cenomanian stage of France, during the last forty years, it is remarkable that no true second species has been found. It has often occurred to me that this is one of many problems of a like nature that the disciples of Darwin might attempt to

solve. The geological record of the Cretaceous rocks where the SALENIDÆ abound is not so imperfect as many assert, and connecting forms, if such ever really existed, ought to be found somewhere in beds that are so often searched and so diligently worked for the Palæontological treasures they contain. Notwithstanding all this investigation, *Goniophorus lunulatus* still remains an isolated genus represented by a single species among the SALENIDÆ.

Genus—SALENIA, *Gray*, 1835.

SALENIA, *Agassiz*, 1838. SALENIA, *Desor*, 1858. SALENIA, *Cotteau*, 1864.

Test small, circular, moderately elevated, sides inflated, more or less convex above and flat beneath; poriferous zones narrow, pores unigeminal, simple in the zones, and crowded near the peristome; ambulacral areas narrow, gently flexuous, with two or four rows of close-set homogeneous mammillated granules. Inter-ambulacral areas wide, with two rows of large crenulated imperforate tubercles.

Mouth-opening nearly two thirds the diameter of the test; peristome divided into ten unequal lobes by feeble incisions; vent circular, periprocte elevated, excentral, and posterior, placed at the right side of the axial line of the body; apical disc shield-shaped, covering a large portion of the dorsal surface; plates prominent, with a deeply undulated border; the ovarials and suranal large and pentagonal, the oculars wide and cordate; the sutures punctuated or incised, and the surface of the plates smooth in *S. petalifera*, sometimes granulated, in *S. granulosa*, or striated with geometrical lines forming various figures, as in *S. Clarkii* and *S. Austeni*.

The right antero-lateral ovarial plate exhibits a slight laceration, in which the madreporiform body is sometimes seen in well-preserved specimens; often it is invisible.

The spines are known only in a few species; in some they are long, slender, and aciculate; in others they are stronger, with spatulate terminations (Pl. XXXVIII, fig. 2); some rarer specimens have their stems flexed, and others have the extremities bent to right angles with the stem (Pl. XXXVIII, fig. 3; Pl. XLII, figs. 1, 2, 3, 4, 5).

The genus *Salenia* is distinguished from *Heterosalenia* and *Pseudosalenia* by its imperforate tubercles, and from *Peltastes*, which it very much resembles, by the position of the vent. In *Salenia* the periprocte opens excentrically on the right side of a line passing through the axis of the body, whilst in *Peltastes* the periprocte lies in the centre of such an axial prolongation.

A.—*Species from the Upper Greensand.*

SALENIA PETALIFERA, *Desmarest*, sp., 1825. Pl. XXXIII; Pl. XLII, fig. 3.

ECHINITE, from Wiltshire,		*Parkinson.* Organic Remains, vol. iii, pl. i, fig. 12, 1811.
ECHINUS,		*W. Smith.* Strata identified by Organized Fossils, p. 12, Greensand, fig. ii, 1816.
—	AREOLATUS,	*König.* Icones foss. sectiles, fig. 100, 1820.
—	PETALIFERUS,	*Desmarest.* Oursin; Dict. Sc. Nat., t. xxxvii, p. 101, 1825.
—	—	*De Blainville.* Zoophytes, Ibid., t. lx, p. 210, 1830.
—	—	*Desmoulins.* Études sur les Échinides, p. 302, 1837.
SALENIA PETALIFERA,		*Agassiz.* Monogr. des Salénies, p. 9, pl. i, figs. 17—24, 1838.
—	—	*Agassiz.* Catal. Ectyp. foss., p. 11, 1840.
—	—	*Dujardin.* In Lamarck's Animaux sans Vert., 2e éd., t. iii, p. 394, 1840.
—	—	*Morris.* Catalogue of British Fossils, p. 58, 1843.
—	PERSONATA,	*Agassiz* et *Desor.* Catal. rais. des Échinides, Ann. Sc. Nat., 3e série, t. vi, p. 341, 1846.
—	—	*Forbes.* Mem. of Geol. Surv., Decade I, pl. v, 1849.
—	PETALIFERA,	*Bronn.* Index Palæontologicus, p. 1107, 1849.
—	PERSONATA,	*d'Orbigny.* Prodrome de Pal. strat., t. ii, p. 179, 1850.
—	—	*d'Orbigny.* Cours élément. de Pal., t. ii, p. 126, fig. 277, 1851.
—	PETALIFERA,	*Bronn.* Lethæa Geog. Kreide-Geb., pl. xxix, fig. 15, 1852.
—	PERSONATA,	*John Müller.* Ueber den Bau der Echinodermen, p. 7, pl. i, fig. 15, 1854.
—	PETALIFERA,	*Forbes.* In Morris's Catal. of Brit. Foss., p. 89, 1854.
—	—	*Desor.* Synopsis des Échinides foss., p. 149, pl. xx, figs. 1—3, 1856.
—	PERSONATA,	*Pictet.* Traité de Paléontologie, t. iv, p. 247, pl. xcvii, fig. 1, 1857.
—	PETALIFERA,	*Cotteau.* Paléontologie Française, Terrain crétacé, tom. vii, p. 144, pl. 1034, 1864.

Diagnosis.—Test circular, depressed, upper surface convex, sides inflated, base narrow, concave; ambulacra wide, prominent, flexed, two complete rows of large marginal, and two incomplete rows of small central granules. Inter-ambulacra three times the width of ambulacra, two rows of tubercles, six in each, large above the ambitus, small below; miliary zone wide, sparsely granulated; apical disc smooth, large, margin undulated, sutures marked with punctuations; vent circular, periprocte thin and prominent.

Dimensions.—Altitude, four tenths of an inch; latitude, seven tenths of an inch.

Description.—This beautiful Urchin, so long known to collectors of Upper Greensand fossils, has a subglobose body, depressed above, flat below, and with inflated sides; the ambulacral areas, gently flexed, stand out more prominently than the inter-ambulacrals; they have two complete rows of larger granules on the margins of the area, and two incomplete rows of smaller ones within (fig. 1 *c, d*, and fig. 2 *b*); the poriferous zones are very narrow, depressed, and much flexed, and the pores, which are unigeminal throughout (fig. 1 *d*), are arranged in oblique pairs, separated by a prominent tubercle on the septum (fig. 2 *b*). The inter-ambulacral spaces are three times as wide as the ambulacral, with two rows of tubercles, having six in each row, those above the ambitus are large and well developed (fig. 1 *b*, *d*), those below are small, and decrease much in size as they approach the peristome (fig. 2 *a*); the base acquires an ornamented appearance from the number of small primary tubercles that adorn it (fig. 2 *a*). Each tubercle is surrounded by a wide areola, around which a more or less complete circle of large granules is regularly arranged (fig. 1 *d*), and most of these granules are mammillated; the miliary zone is wide below, and increases in diameter above; throughout it is covered with small granules nearly of the same size (fig. 1 *c* and *d*). At the base of the area the primary tubercles and granules are disposed as in fig. 3, where a portion of the area is magnified six times; and a profile of one tubercle is given in fig. 4, magnified four times.

The base is flat, and concave towards the centre, the mouth-opening, one third the diameter of the test, is sunk in a depression; the peristome is deeply incised, and divided into ten nearly equal-sized lobes (fig. 2 *a*, fig. 4 *b*).

The apical disc forms a very regular structure in this species; the antero-lateral and postero-lateral ovarial plates have a rhomboidal figure, and the single or suranal plate is smaller in consequence of the position of the vent; the oviductal holes are perforated near the centre of the plates; and the madreporiform body is seen as a slight laceration on the surface of the right antero-lateral in some well-preserved specimens only. The ocular plates are much smaller, and transversely or subtriangularly oblong, their inner sides forming the prominent portions of the triangle, and their frontal margins the bases. The suranal plate occupies the centre of the disc before the vent; it is nearly as large, and of the same form as one of the ovarials, and the lines of the sutures present many punctuations. At the angles of junction of every three plates is a deep punctuation, and another in the line of union between every two plates. Thus there are nine punctuations around the borders of the three anterior ovarials, six around each of the posterior ovarials, and three around the oculars (fig. 1 *e*, *b*). The pits at the junction of three plates are triangular, and those at the junction of two circular; they are never prolonged as linear notches into the substance of the plates, as in *Peltastes clathratus* and *P. Bunburyi*. The vent is subcircular, excentral, and inclines to the right side; the periprocte is elevated and prominent, and bordered by a rim formed of the elevated margins of the suranal, right postero-lateral, and single ovarial plates. There is considerable variation in the size of the punctuations and the width of the lines of suture; but these variations have all their

connecting links, and fall within the general description given of the punctuations on the sutural lines of the discal elements.

Affinities and Differences.—*Salenia petalifera* forms an excellent type of the true *Salenia*, and a leading fossil of the beds in which it is contained. I cannot appreciate the differences which some naturalists point out between this species and *S. scutigera*, Münster; and as I have never seen a true type of that species, I must reserve my opinion until I can make a comparison between them. After many careful examinations of Herr Hohe's figure in the 'Petrefacta,' and knowing the extreme accuracy and truthfulness of that excellent artist's admirable drawing, I am inclined to think that *Cidarites scutiger*, Münster, is only a smaller form of *S. petalifera*, Desm.; but as most competent authorities have ruled it otherwise, I have not put *S. scutigera* in my list of synonyms.

S. petalifera resembles *S. Austeni*, Forb.; the latter, however, has a more elevated test with a smaller apical disc, and more prominent periprocte. It very much resembles *Salenia gibba*, from the same stratum of Upper Greensand, which may be only a variety of *S. petalifera:* a closer comparison between these two allied forms will be found in the description of *S. gibba*.

Locality and Stratigraphical Position.—*Salenia petalifera* was at one time an abundant fossil in the Upper Greensand of Longleat, Wilts; but has now become more rare. It is collected from the Grey Chalk near Folkestone, where some very fine examples are sometimes obtained. I have long noticed that nearly all the Upper Greensand Echinidæ are found in the Grey Chalk, and that the specimens from the latter stratum are in general larger and more fully developed, as if they had been better nourished, than those collected from the arenaceous beds of the Upper Greensand of Wilts and other localities.

History.—This Urchin has long been considered to be a leading English fossil of the Upper Greensand; and Parkinson, 1811, Smith, 1816, König, 1820, have all given good figures of this Echinite.

Foreign Distribution.—In the Craie Chloritée de Cap-la-Hève, and other parts of France, in Bavaria and Minorca, and in the "Hils-Conglomerat" of North Germany.

Salenia Loriolii, *Wright*, nov. sp. Pl. XXXV, fig. 1 *a*—*d*.

Diagnosis.—Test small, circular, depressed; upper and under surfaces flattened; ambulacra straight, narrow, two rows of marginal homogeneous granules; interambulacra wide, four or five tubercles in each row; decreasing gradually in size from above downwards; apical disc large, border slightly undulated, surface flat, smooth; ovarial plates without sutural lines or punctuations in the middle of the disc, and with ten round apertures near the outer border; mouth-opening large, peristome deeply incised, lobes unequal.

Dimensions.—Altitude, two lines; latitude, four lines.

Description.—This small Urchin exhibits a form of apical disc very unusual among the

Salenidæ. The test is depressed on the upper and under surfaces, and the sides are inflated between. The poriferous zones are narrow, and the pores unigeminal throughout. The ambulacral areas are straight and narrow, with twelve pairs of marginal, close-set, homogeneous granules, and a few granulations between them at the widest part thereof (fig. 1 *d*). The inter-ambulacral areas are wide, and filled with two rows of large tubercles, four in each row; those in the upper part of the area are the largest, and they gradually diminish in size from above downwards; the bosses of the tubercles are very prominent, and their summits sharply crenulated; the mammillon likewise is large (fig. 1 *d*). Two rows of large granules occupy the miliary zone, and describe a zig-zag ornamentation on each side of the mesial suture, and two granules occupy the angles of each of the plates at their zonal side, so that the test of this small species has a highly ornamented appearance (fig. 1 *c*, *d*).

The apical disc is large, solid, and remarkable for the absence from its ovarial plates of sutural lines or punctuations; its border is thickened, and recurved, and near this marginal bourrelet are ten wide equidistant punctures (fig. 1 *a*); the vent is round, the periprocte annulated, not much elevated, and slightly excentral (fig. 1 *a*, *c*).

The mouth-opening is very large, one half the diameter of the test; the peristome is deeply incised, and the oral lobes are slightly unequal (fig. 1 *b*).

Affinities and Differences.—*Salenia Loriolii* resembles *Salenia minima* in the closely united sutures of its apical disc, but differs from it in the larger development of its tubercles and wideness of its mouth-opening. It differs from *Salenia Desori*, associated with it in the same "terrain" in which it is found, in possessing larger tubercles, a smooth disc without punctuations, and a much larger mouth-opening. A comparison of the capital figures of these two *Saleniæ* on the same plate places their affinities and differences better before the student than any verbal description.

Locality and Stratigraphical Position.—This rare specimen belongs to the British Museum, and was collected from the Upper Greensand near Warminster.

I have dedicated this Urchin to my friend Monsieur P. de Loriol, of Geneva, one of the learned authors of the 'Échinologie Helvétique,' and of several other important works on the Geology and Palæontology of Switzerland.

Salenia Desori, *Wright*, nov. sp. Pl. XXXV fig. 2 *a*—*f*.

Diagnosis.—Test small, circular, depressed, upper surface convex; ambulacra straight, narrow, with two rows of mammillated granules; inter-ambulacra wide, four or five moderate-sized tubercles in each row; pores unigeminal throughout; apical disc prominent, with large punctuations along the sutural lines; mouth-opening moderate; peristome deeply incised; lobes nearly equal.

Dimensions.—Latitude, four and a half lines; altitude, two and a half lines.

Description.—This pretty little *Salenia* was collected with *S. Loriolii* in the Upper

Greensand of Wiltshire. The test is small and circular; the upper surface convex, and the base flat; the sides are inflated, and the disc conspicuous and prominent.

The ambulacral areas are straight, with two rows of prominent homogeneous granules on their margins, and oblique rows of small granulations, three in each, between every pair of marginal granules (fig. 2 *f*, 2 *c*). The pores are unigeminal, the pairs slightly oblique, and the zones narrow and straight.

The inter-ambulacral areas are wide, and the two rows of primary tubercles are placed close to the pores, so that the miliary zone is wide and filled with granules of different sizes (fig. 2 *c*); the tubercles are of moderate dimensions, and gradually decrease from above downwards. Four of the five sides of each plate are encircled with a row of mammillated granules (fig. 2 *f*).

The apical disc is large, solid, and prominent, the border gently undulated, and the sutural lines soldered up; in lieu thereof, there are three large punctuations between the junctions of the three anterior ovarial and sur-anal plates, and between all the ocular plates and ovarials; the oviductal holes are large; the vent is round; the periprocte thickened, prominent, and slightly excentral (fig. 2 *a*, 2 *d*).

The mouth-opening is nearly half the diameter of the test; the peristome is deeply incised, and the lobes are nearly equal (fig. 2 *b*).

Affinities and Differences.—*Salenia Desori* resembles *S. gibba*. It has, however, fewer granules in the ambulacra, the inter-ambulacra are more regularly developed, the apical disc is without sutures, and the mouth-opening is larger in proportion to the diameter of the test.

Locality and Stratigraphical Position.—This rare Urchin was collected from the Upper Greensand near Warminster. I have dedicated it to my friend Professor E. Desor, of Neuchatel, one of the learned authors of the 'Catalogue raisonné des Échinides' and 'Échinologie Helvetique,' and author of the 'Synopsis des Échinides fossiles' and many other valuable works on natural science.

Salenia gibba, *Agassiz*. Pl. XXXIV, fig. 4 *a*, *b*, *c*, *d*, *e*.

Salenia gibba, *Agassiz*. Monogr. des Salénies, p. 13, pl. ii, figs. 9—16, 1838.
— — *Agassiz* et *Desor*. Catalog. rais. des Échinides, Ann. Sc. Nat., 3e série, t. vi, p. 341, 1846.
— — *Bronn*. Index Palæontologicus, p. 1107, 1847.
— — *d'Orbigny*. Prod. de Pal. strat., t. ii, p. 180, 1850.
— — *Morris*. Catalogue of British Fossils, 2nd ed., p. 89, 1856.
— — *Pictet*. Traité de Paléontologie, t. iv, p. 248, 1857.
— — *Cotteau*. Paléontologie Française, Terrain crétacé, tom. vii, p. 151, pl. 1035, figs. 13—20, 1865.

Diagnosis.—Test small, circular, upper surface inflated, gibbous, under surface flat,

sides rounded; ambulacra narrow, flexed, two rows of marginal, closely set, mammillated granules, with intermediate granulation; poriferous zones flexed; pores small, oblique, unigeminal; inter-ambulacra wide, tubercles large and prominent above, four or five in a row. Apical disc thick, gibbous, subconical; sutural impressions deep, punctuations large, vent circular, periprocte elevated.

Dimensions.—Specimen *a*. Altitude, two lines; latitude, four lines.

„ *b*. Altitude, five lines; latitude, six lines.

Description.—The type specimens of this species figured by Professor Agassiz and M. Cotteau, from the Cenomanian of France, have a more elevated gibbous test than any of the specimens referred to *Salenia gibba* that I have seen from the Upper Greensand of England. The shell is small and circular, the upper surface elevated, the under surface flat, and the sides inflated. The ambulacral areas are narrow, and flexed in their upper third; they have two rows of mammillated marginal granules set close together, from eighteen to twenty in a series (fig. 4 *e*), and the surface of the space between the granules is covered with a microscopic granulation. The poriferous zones are depressed, and follow the flexures of the areas; the pores are small, round, and unigeminal, and disposed in oblique pairs, the two pores forming a pair being separated by a septal granule (fig. 4 *e*).

The inter-ambulacral areas are wide, and the tubercles, of which there are four or five in a series, are large, prominent, and distant at the upper surface, and small, granuliform, and closely set together below (fig. 4 *b* and *e*); the miliary zone is narrow and sinuous, and provided with unequal granules; some of these are large and mammillated, and disposed around the primary tubercles in incomplete circles; others are smaller, and fill the lower portion of the zone with a sparse granulation.

The apical disc is thick, irregularly round and prominent (fig. 4 *c*, *d*), and the plates are unequal. The sutures are open and incised, and the punctures deep; in some specimens figured by M. Cotteau the disc is thick, gibbous, and subconical, and the impressions are wide and deep; the surface of the ovarial plates has small attenuated elevations, which converge at the centre of the plates. The ocular plates are sub-triangular, and appear to be perforated in the middle; the sur-anal plate is large and thick, and the oviductal lobes pierce the centre of the plates (fig. 4 *d*). The vent is sub-circular, and the periprocte prominent, with an annular projecting border.

The mouth-opening is small, rather more than one third the diameter of the test (fig. 4 *b*). The peristome is slightly incised, and the oral lobes are nearly equal.

Affinities and Differences.—In his 'Synopsis des Échinides fossiles,' my friend Professor Desor considers *S. gibba* as simply a variety of *S. scutigera;* it appears, however, to have a more inflated gibbous form, with more flexuous ambulacra, a thicker apical disc, more unequal in outline, and marked with larger and deeper perforations; and the mouth-opening is likewise proportionally smaller.

The structure of the apical disc allies *S. gibba* to *S. Bourgeoisi;* the test of the

latter is much less inflated, the apical disc thinner and more depressed, the ambulacra are straighter, and the mouth-opening wider.

Locality and Stratigraphical Position.—The specimen I have figured belongs to the British Museum, and was collected from the Upper Greensand near Longleat, Wilts, where it is extremely rare. This species appears to be equally scarce in France; as it was obtained from the Cenomanian = Upper Greensand, in the "Ile d'Aix" (Charente-Inférieure). From this locality the type specimens in the Musée de Paris and others in private collections were collected.

B.—*Species from the Grey Chalk.*

SALENIA AUSTENI, *Forbes.* Pl. XXXVII, figs. 1, 2.

SALENIA AUSTENI, *Forbes*, MS. Woodward, Mem. Geol. Surv., Decade V, App., 1856.
— — *Forbes.* In Morris's Catalogue of British Fossils, p. 89, 1854.

Diagnosis.—Test tumid, more or less elevated; ambulacra prominent, slightly flexed, two complete rows of remote marginal granules and two incomplete rows of smaller granules within; inter-ambulacra with two rows of tubercles, five in each, decreasing in size from above the ambitus to the peristome. Miliary zone wide, sparsely covered with granules. Apical disc small, thick, prominent; sutures marked by regular punctuations; vent elevated, periprocte projecting, having a sharply crenulated border.

Dimensions.—Altitude, five tenths of an inch; latitude, seven tenths of an inch.

Description.—This beautiful *Salenia* has in general a tumid body, with a narrow base, inflated at the sides, and convex on the upper surface, the vent being very excentric, elevated, and prominent; in some examples, however, the upper surface is more or less depressed, and approaches the form of *S. petalifera.*

The ambulacral areas are narrow, nearly straight, and very prominent; they have two complete rows of remote marginal granules, twenty-four in each (fig. 1 *d*), and two incomplete rows of smaller central granules, which occupy two thirds of the area (fig. 1 *f*). The poriferous zones are narrow and slightly flexed; the pores are very small, oblique, and unigeminal, ten pairs occupying the height of a single plate (fig. 1 *f* and *g*).

The inter-ambulacral areas are wide, and regularly developed (fig. 1 *a*), with two rows of primary tubercles, gradually diminishing in size from the upper to the lower part of the area, those near the disc being large, and those near the peristome small. Fig. 1 *e* shows an entire area magnified four diameters; the tubercles are seated near the poriferous zones; each is surrounded by a wide, areolar space, and around the margin thereof three parts of a circle of six to eight large round granules are placed (fig. 1 *d*, *e*, *g*).

The miliary zone is wide throughout, and sparsely covered with small granules, especially near the discal region (fig. 1 *d*, *e*). The base is concave (fig. 1 *b*), and highly ornamented

by the numerous small close-set tubercles of the inter-ambulacra, the large granules of the ambulacra, and the width of the miliary zones. The mouth-opening is large, more than one third the diameter of the test; the peristome is deeply incised, and forms ten nearly equal-sized lobes (fig. 1 *b*).

The apical disc is small and thick, and rises above the test (fig. 1 *c* and *d*). The two antero-lateral and the left postero-lateral plates have a rhomboidal figure, and are nearly the same size. The right postero-lateral, the single plate, and the suranal are small in consequence of the encroachment of the vent; the posterior border of the suranal is thickened and elevated (fig. 1 *c*, *d*, *i*), and rises to form the anterior wall of the periprocte; the sutures between the three anterior ovarial plates are each marked by six deep punctuations, which define their line of junction; and the sutures, uniting the ocular with the ovarial plates, have each three deep punctuations (fig. 1 *c* and fig. 1 *i*). The test I have figured has not the perforations in the ovarial sutures as distinctly marked as the test which now lies before me for description, so that this character varies in different specimens. The vent is round and elevated, and placed near the posterior part of the disc (fig. 1 *c*). The periprocte projects upward and backward (fig. 1 *a* and *d*), and forms a crenulated rim around the aperture (fig. 1 *a*, fig. 1 *d*, and fig. 1 *i*).

Affinities and Differences.—In a large majority of specimens the general form of the body in *S. Austeni* differs from *S. petalifera* in being more globose and elevated. The apical disc is smaller in diameter, and thicker in substance. The vent is likewise more elevated, the periprocte more produced, and its margin sharply crenulated. In the structure of the areas, such as the character of the granules in the ambulacra, and the tubercles in the inter-ambulacra, there is a close resemblance between these portions of the test in both species.

Locality and Stratigraphical Position.—*S. Austeni* is the most abundant species in the Lower or Grey Chalk, near Folkestone; from this locality and stratum it has been collected by my kind friend, the Rev. T. Wiltshire, F.G.S., to whom I am indebted for several fine specimens given to help me in my work.

History.—Named by the late Professor Edward Forbes, but not described by him. A brief diagnosis of the species was given by my late friend Dr. Woodward, in the Appendix to the Fifth Decade of the 'Memoirs of the Geological Survey.' It is now figured and described in detail for the first time.

SALENIA CLARKII, *Forbes*. Pl. XXXVIII, fig. 1; Pl. XXXIX, fig. 1; Pl. XLII, figs. 1, 2, 5.

SALENIA CLARKII, *Forbes*. In Morris's Catalogue of British Fossils, p. 89, 1856.
— — *Woodward*. Mem. Geol. Surv., Decade V, App., p. 5, 1856.

Diagnosis.—Test globose, elevated, flattened on the upper and under surfaces;

ambulacra narrow, two complete rows of marginal granules, and a few small central; inter-ambulacra wide, two rows of primary tubercles large in the upper part, small below; apical disc half the diameter of the test, plates roughened with raised points; each ovarial plate with five furrows leading to the large sutural pores. Spines slender, cylindrical, finely striated and granulated, the longest exceeding $1\frac{3}{4}$ inches in length, and less than one line in diameter; frequently forked at their extremities, and sometimes bent and otherwise distorted.

Dimensions.—Height, nine twentieths of an inch; latitude, thirteen twentieths of an inch.

Description.—This very distinct form of *Salenia* has an elevated body, depressed and flattened on the upper and under surfaces; the ambulacral areas are narrow and straight (fig. 1 *d*,) with two complete rows of marginal granules, about twenty in each; within these are two incomplete rows of small irregular granules, having a microscopic granulation scattered around their base. Fig. 1 *g* shows an ambulacral area magnified four times, and exhibits the increase in volume of the marginal granules near the base of the area. The poriferous zones are narrow; the pores form oblique pairs with a thick septum between, and having a small granular elevation on the surface: fig. 1 *h* shows this structure magnified six diameters, as well as the minute granulation on the surface of the plates, and the comparative sizes of the marginal and central granules in the area. The number of pores opposite each large plate is eight or nine pairs.

The inter-ambulacral areas are wide above and narrow below; there are six primary tubercles in each of the two rows, and of these the four above the ambitus are much the largest; those on the under side are much smaller and set closely together; all the tubercles have wide areolar spaces, which are encircled for three parts of their circumference with a series of large, remote, well-developed granules. Fig. 1 *f* shows an entire inter-ambulacral space magnified four diameters, and fig. 1 *h* a single plate with its primary tubercle, areolar space, and circle of marginal granules, with the poriferous zones and ambulacra, magnified six diameters. The miliary zone (fig. 1 *f*) is wider below the ambitus, and is here filled with an abundant granulation (fig. 1 *c*, fig. 1 *f*); above the ambitus, the large size of the tubercles diminishes the width of the zone, and the tubercles here are fewer and larger (fig. 1 *f*, fig. 1 *b*, and fig. 1 *d*).

The apical disc is one half the diameter of the test, and the surface of the plates is roughened with many raised points (fig. 1 *b*); each ovarial plate has five furrows leading to the sutural pores, which have an arrangement similar to the punctuations on the disc in *S. petalifera*; a semicircle of seven punctures indicates the sutures by which the sur-anal is united to the three anterior ovarials; one large and two smaller punctures mark the line of union between the ocular and ovarial plates. In fig. 1 *e* the apical disc is magnified four diameters; and the sutural punctuations are very correctly delineated in this drawing.

The spines of *Salenia Clarkii* are very well preserved with the test in the unique specimen belonging to the Museum of the Royal School of Mines, and which I have figured

in Pl. XXVIII, fig. 2 *a*. The spines are slender, cylindrical, finely striated, and granulated; the longest exceed $1\frac{3}{4}$ inches in length, and are less than the twelfth of an inch in diameter; some of the spines are bent, as in figures 3 and 4, some are spatulate (fig. 2 *b*), and others are forked (fig. 2 *c*) at their extremities. The base of the spine around the milled ring has fine longitudinal lines extending a short distance up the stem, which is likewise covered by finer microscopic lines (fig. 2 *d*, and figs. 3 and 4) extending along the stem.

Affinities and Differences.—This species very much resembles *S. gibba;* but, according to Dr. Woodward, it is entirely distinct from the mould of Professor Agassiz's original example of that species.

Locality and Stratigraphical Position.—*Salenia Clarkii* is very rare in the Grey Chalk near Folkestone; from this "terrain" the specimens in the Royal School of Mines and the British Museum were obtained.

History.—First named by the late Professor Edward Forbes, in his additions to the Echinodermata in the 2nd edition of Professor Morris's Catalogue of British Fossils. A diagnosis of the species was subsequently drawn up by Dr. Woodward, in his Appendix to Decade V, Memoirs of the Geological Survey, illustrative of Organic Remains. It is now figured in detail from specimens contained in the Cabinet of the Rev. T. Wiltshire, F.G.S., and in both our National Collections.

B.—*Species from the Lower White Chalk.*

SALENIA GRANULOSA, *Forbes.* Pl. XLI, figs. 2, 3; Pl. XLIII, fig. 1 *a*—*h*.

SALENIA SCUTIGERA,	*Forbes.*	In Dixon's Geol. Foss. Sussex, pl. 340, pl. xxv, fig. 24, 1850.
— HELIOPHORA,	*Sorignet.*	Oursins de l'Eure, p. 20, 1850.
— GRANULOSA,	*Forbes.*	In Morris's Catalogue of Brit. Foss., p. 89, 1854.
— —	*Woodward.*	Mem. of Geol. Surv., Dec. V, 1856.
— INCRUSTATA,	*Cotteau,*	in Desor's Synops. des Éch. foss., p. 152, 1856.
— GRANULOSA,	*Pictet.*	Traité de Paléontologie, t. iv, p. 218, 1857.
— —	*Cotteau.*	Paléontologie Française, Terrain Crétacé, tom. vii, p. 167, pl. 1039, figs. 6—21, 1860.

Diagnosis.—Test small, circular, depressed, upper surface convex, under surface flat; ambulacra narrow, slightly flexed, with two rows of marginal mammillated granules; inter-ambulacra wide, much covered by a prolongation of the ovarial plates, tubercles small, surrounded by areolas; apical disc very large, covering like an incrustation nearly the entire upper surface; the flat ovarial plates have flexuous lines of granular processes diverging from their centres, and the convex oculars have similar lines extending over them from their inner side; the sutures smooth, and without impressions.

Dimensions.—Specimen *a*. Altitude, four lines; latitude, five lines.

„ *b*. Altitude, four and a half lines; latitude, six and a half lines.

Description.—This beautiful species was first noticed by M. l'Abbé Sorignet, in his description of 'l'Oursins de l'Eure,' and referred by him to *Hyposalenia heliophora* from the Upper Chalk (Danian) of Ciply, which M. Desor[1] described as "distinguished by its very much ornamented disc, each ovarial and ocular plate being the centre of a system of fine ridges, that radiate in all directions." This species was not figured by Sorignet; and I have not yet seen a French specimen to compare with our Urchin from the lower white gritty Chalk of Dover, where it has hitherto only been found.

The test is small and circular, the upper surface convex, the lower flat, and the sides rounded and moderately inflated (Pl. XLI, fig. 2 *c*; Pl. XLIII, fig. 1 *d*). The ambulacral areas are narrow, straight, or slightly flexed, with two marginal rows of round prominent granules, twelve to thirteen in each; those near the base are large and mammillated (Pl. XLI, fig. 1 *e*); those at the ambitus smaller, and on the upper part very small and closely placed together; the intermediate space being filled with an unequal microscopic granulation, which extends horizontally between the marginal granules.

The poriferous zones are narrow, the pores unigeminal, and set in oblique pairs, separated from each other by a small granuliform elevation of the septum; there are about eight pairs of holes opposite one of the large inter-ambulacral plates (Pl. XLI, fig. 2 *f*; Pl. XLIII, fig. 1 *h*, in which I have given accurate figures of this part of the test, magnified six times).

The inter-ambulacral areas are wide (Pl. XLI, fig. 2 *d*), and covered over in their upper third by a lateral extension of the ovarial plates; there are three or four tubercles in each row, which rise a little above the ambitus; only one or two of these tubercles in each series are well developed, surrounded by a circular areola, and having a large boss and prominent mammillon (Pl. XLIII, fig. 1 *h*; Pl. XLI, fig. 2 *f*). The miliary zone is narrow, and its granules unequal in size and structure; the larger are distinctly mammillated, and disposed in a regular crescentic form around the areolæ; where the latter abut against the poriferous zones the granules are absent (fig. 1 *h*, fig. 1 *g*); the other granules are small and irregularly disposed, filling up the space with a fine granulation (fig. 1 *h*).

The mouth-opening is very small (Pl. XLI, fig. 2 *b*; Pl. XLIII, fig. 1 *c*), in excess of one third the diameter of the test; the peristome is divided into ten equal lobes by well-marked incisions.

The apical disc is very large and pentagonal, occupying a great part of the upper surface (Pl. XLIII, fig. 1 *b*, *d*, *e*). It is convex above, and so thin and closely adherent to the shell at the borders that it appears to blend with the plates of the test; the ovarial plates are large, and of an irregular form; their surface is sculptured with small unequal punctuated lines, which appear to radiate outwards from the oviductal holes situate near

[1] 'Synopsis des Échinides fossiles,' p. 148.

the centre of the plate; the ridges on the plates resemble numbers of prominent granulations projecting outwards, which impart a granulose aspect to the surface of the disc, and is very well represented in Pl. XLI, fig. 3, and Pl. XLIII, fig. 1 *e;* a process of each plate extends into the inter-ambulacra, the ornamentation of which differs from that in the middle of the plate; the punctuated lines are widest and more flexed, and this incrusting process appears to blend with the granulations on the test; the sur-anal plate is elevated, and forms the anterior border of the periprocte; the ocular plates are heart-shaped, and more prominent than the ovarials; they are likewise covered with punctuated flexuous ridges, but the lines are more tortuous, and the style of ornamentation is different (Pl. XLIII, fig. 1 *e*) from that on the ovarials.

The spines are not preserved in any of the Dover specimens that have passed through my hands. M. Cotteau, however, describes them as elongate or aciculate, cylindrical, or a little compressed, provided with fine longitudinal sub-granular striæ; their greatest diameter is near the neck of the spine, and they regularly diminish to the upper extremity, which is pointed. The collarette is short or absent, the milled ring very prominent and strongly striated, and the rim of the articular cavity crenulated.

Affinities and Differences.—*Salenia granulosa*, Forb., strongly resembles *Hyposalenia heliophora*, Desor, from the Chalk of Maestricht; it is distinguished from it, however, according to M. Cotteau, by being smaller in size, and having its upper surface more conical, its ambulacra furnished below the ambitus with smaller granules, and in possessing fewer primary tubercles in the inter-ambulacra; the apical disc is thinner and distinctly circumscribed, the flexuous ridges on the ovarial and ocular plates are more irregular and more granular, and the periprocte is situated to the right of the axis.

Locality and Stratigraphical Position.—This fine species is found in the hard gritty whitish beds of the Lower Chalk at Dover, where it is associated with *Cyphosoma simplex*, Forb., and numerous *Polyzoa*. All the specimens I have examined were obtained from this one locality, where it is rather rare.

M. Cotteau states that it is a common species in the Étage Sénonien of Vernonnet, Giverny, Petit-Andely, Penterville (Eure), and the environs of Beauvais (Oise).

History.—M. l'Abbé Sorignet first described in 1850 this *Salenia* in his interesting memoir 'l'Oursins de l'Eure,' and identified it as the *Hyposalenia heliophora*, Desor. In the same year the late Professor Forbes, in Dixon's 'Geology of Sussex,' gave a figure of this Urchin, which he referred to *Salenia scutigera*, Gray; subsequently, in the second edition of Morris's 'Catalogue of British Fossils,' 1854, Forbes separated it from that species under the MS. name *S. granulosa*. In 1856 M. Cotteau, in M. Desor's 'Synopsis des Échinides fossiles,' named the specimens collected and identified as *Hyposalenia heliophora* by M. Sorignet, *Salenia incrustata*, Cott.; he gave the following diagnosis of this form :—"Small Urchins, well characterized by their very large apical disc, thin, and little in relief, and incrusting in some manner the whole of the upper surface of the test. The ovarial plates present a series of small points disposed like rays around many centres;

the disc is so intimately soldered to the test that it is sometimes difficult at first sight to recognize its limits." A comparison of the English with the French specimens showed them to be specifically identical, and thus M. Sorignet was the discoverer, but Forbes the namer, of this well defined species.

c.—*Species from the Upper White Chalk.*

SALENIA GEOMETRICA, *Agassiz*, 1838. Pl. XLIII, fig. 2 *a*—*g*, fig. 3 *a*, *b*.

SALENIA	GEOMETRICA,	*Agassiz*. Mongr. Échinodermes, pl. i, figs. 25—32, p. 11, 1838.
CIDARIS ?	VESICULOSUS,	*Portlock*. Report on the Geology of Londonderry, pl. xviii, fig. 5, p. 358, 1843.
SALENIA	SCUTIGERA ?	*Forbes*. In Dixon's Geology of Sussex, pl. xxv, fig. 23, 1850.
—	PORTLOCKII,	*Forbes*. In Morris's Cat. of Brit. Foss., 2nd ed., p. 89, 1854.
—	—	*Woodward*. Mem. of the Geol. Surv., Decade V, Append., p. 5, 1856.
—	GEOMETRICA,	*Cotteau* et *Triger*. Échinides du Départ. de la Sarthe, pl. xlvi, figs. 1—7, 1860.
—	SCUTIGERA,	*Cotteau*, pars. Paléontologie Française, Terrain Crétacé, tom. vii, p. 154, pl. 1036, 1864.

Diagnosis.—Test sub-globose, elevated, convex above, contracted and concave beneath; ambulacra narrow, slightly flexuous, marginal granules separated by two rows of granulets; inter-ambulacra wide, plates slightly radiate; two rows of tubercles, seven to eight in each, the ambital large, the basal small; miliary zone with large sparse granules and minute granulations; apical disc moderate, of a regular geometrical figure, flattened, two thirds the diameter of test; sutures punctuated; plates nearly equal in size; mouth-opening small, one third the diameter of test.

Dimensions.—*a*. Altitude, eight lines; latitude, nine lines (Mr. Searles Wood's specimen).

b. Altitude, eleven lines; latitude, one inch (Mr. King's specimen).

Description.—The species to which this Urchin has been referred is considered by Professor Desor and M. Cotteau to be the *Salenia scutigera*, Gray; as I am doubtful about the identity of Dr. Gray's form, I have retained the name given by Professor Agassiz, seeing that he has published good figures and a clear description of this species in his beautiful Monograph on the Salénies. *S. geometrica* is the largest species of the genus at present known. The test is elevated and sub-globose, slightly flattened at the upper and under surfaces. The ambulacral areas are narrow and slightly flexed, with two marginal rows of close-set granules, fourteen to sixteen in each, and separated by a double row of minute granulation extending down the middle of the area (Pl. XLIII, fig. 2 *c*, *g*, *f*). The poriferous zones are narrow and slightly flexed, the pores unigeminal

and oblique (fig. 2 *f*), and the septa between the pores support prominent granuliform elevations (fig. 2 *g*).

The inter-ambulacral areas are very wide throughout (fig. 2 *c*, *e*, and fig. 3 *a*, *b*) ; they are formed of two series of deep plates, seven in each, that support large prominent tubercles (fig. 2 *e*, *g*, fig. 3 *a*). The four ambital tubercles are the largest ; they have well-defined areolas, prominent bosses, and moderate-sized mammelons. A series of mammillated granules surround the areola, except where it abuts against the zones (fig. 2 *e* and *g*). The miliary zone is wide, and filled with numerous small granulations (fig. 2 *e*) in addition to the larger granules that encircle the tubercles.

The apical disc, two thirds the diameter of the test, has a regular geometrical figure, hence the origin of the specific name (fig. 2 *a*, *b*) ; it is circular, slightly convex, and a little elevated at the vent. The ovarial plates have an irregular hexagonal shape, their outer sides are elongated and contracted, and the rounded external border lies within the circle described by the ocular plates, which have an irregular triangular figure, the largest side being turned outwards and slightly undulated (fig. 2 *d*) ; the sutures are fine, distinct, and regularly interrupted by small punctuated angular impressions ; the oviductal holes open in the middle of the plates, and the orbits lie under the central projecting process (fig. 2 *d*) ; the surface of all the plates is quite smooth. The vent is slightly elevated, and the periprocte surrounded by a thick annulus (fig. 2 *b*, *d*) ; this aperture, nearly circular, occupies the posterior half of the sur-anal and the anterior halves of the two posterior ovarial plates.

The mouth-opening is one third the diameter of the test (fig. 3 *b*) ; and the peristome is divided into ten unequal lobes.

Affinities and Differences.—Salenia geometrica resembles *S. scutigera ;* by some authors it is considered to be a large variety of the latter. M. Cotteau, in his beautiful Monograph on the 'Échinides du Département de la Sarthe,' figured and described this Urchin under the name *Salenia geometrica*, Ag., but in his later and most valuable contribution to the 'Paléontologie Française' has united it with *Salenia scutigera ;* he says, however,[1] as to the *Salenia geometrica,* " la question est plus délicate et plus difficile à résoudre. Au premier abord, cette espèce se distingue certainement du *Salenia scutigera* par plusieurs caractères importants : sa taille est beaucoup plus considérable, car sa hauteur dépasse souvent 13 millimètres, et son diamètre 17 millimètres ; sa face supérieure est plus élevée et plus sensiblement déprimée au sommet ; ses tubercules inter-ambulacraires sont plus nombreux, et la zone miliare qui les sépare plus large, plus droite et plus granuleuse ; ses ambulacres sont plus longs et plus flexueux, et l'appareil apicial, relativement moins grand et moins épais, affecte une forme plus pentagonale. Ces différences se reproduisent chez un certain nombre d'individus avec une constance qui n'est pas sans leur donner de la valeur ; aussi, dans nos 'Échinides de la Sarthe,' n'avons-nous pas hésité à maintenir la *S. geometrica* comme une espèce parfaitement distincte.

[1] 'Paléontologie Française, Ter. Crétacé,' tom. vii, p. 157.

"Les nombreux matériaux que nous avons sous les yeux, et que nous venons de comparer, nous engagent aujourd'hui à revenir sur cette opinion. Associés aux types les mieux caractérisés il se rencontre des exemplaires chez lesquels les differences que nous venons d'énumérer s'effacent plus ou moins, et qui tendent à se rapprocher, par des passages insensibles, du véritable *S. scutigera*. Les uns, tout en conservant leur grande taille, sont moins renflés, garnis de tubercules moins abondants, et présentent un appareil apicial plus développé, plus épuis et arrondi au pourtour; les autres, plus petits, ont un appareil apicial qui cesse peu à peu d'être pentagonal, et tend, en s'agrandissant à s'arrondir sur les bords. Ils appartiennent encore à la variété *geometrica;* cependant ils offrent une grande ressemblance avec les exemplaires Cénomaniens; quelquefois même il est difficile de les en séparer.

"Woodward, d'après Forbes, decrit sous le nom de *S. Portlockii* une espèce d'assez grande taille, élevée, sub-globuleuse, à ambulacres étroits et sinueux, à disque apicial médiocrement développé; ses caractères la rapprochent beaucoup du *S. scutigera,* var. *geometrica*. Peut-être devrait-elle y être réunie."

Locality and Stratigraphical Position.—This fine large species occurs in the Upper Chalk of the North of Ireland, where it was collected by the officers of the Geological Survey, and figured in Colonel Portlock's 'Report on the Geology of the County of Londonderry.' It is found very rarely in the upper beds of white Chalk at Norwich and in Sussex, and flint moulds are not uncommon in the Gravel of Norfolk. The specimens figured belong to the British Museum. Mr. Searles Wood possesses a good example, and Mr. John King, of Norwich, has a large one which measures eleven lines in height and as much in diameter. There is also a fine specimen in the Hunterian Collection, Museum of the College of Surgeons (Woodward).

SALENIA MAGNIFICA, *Wright*, nov. sp. Pl. XLIV, fig. 1, *a—l*.

Diagnosis.—Test spheroidal, much elevated; ambulacra nearly straight, two marginal rows of large mammillated and two internal rows of smaller granules; poriferous zones narrow, pores very oblique and unigeminal; inter-ambulacra wide, two rows of tubercles, seven in each, the ambital and dorsal very large, the basal very small; miliary zone wide, and sparsely covered with granulations; apical disc large, plates smooth, sutures punctuated, vent large, oblong; periprocte hexagonal, elevated, and projecting; mouth-opening small, oblong.

Dimensions.—Altitude, nine lines; latitude, ten and a half lines.

Description.—This magnificent *Salenia* from the White Chalk belongs to the British Museum, and to the illustration of its finely preserved details I have devoted Pl. XLIV. The test is spheroidal and much elevated, its altitude exceeding its diameter by one and a half lines; the ambulacral areas are narrow and slightly flexed, with two marginal rows of large

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ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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close-set mammillated granules, twenty-six in each row, larger at the base than in the upper part of the area. Within these are two rows of much smaller granules, twenty-two in each, less regular in their arrangement than the marginal rows (fig. 1 *g*). The poriferous zones are extremely narrow and the pores disposed in very oblique pairs (fig. 1 *g*), eight lying within the height of one of the large inter-ambulacral plates (fig. 1 *i*); the septum between each pair terminates in a granuliform elevation (fig. 1 *i*).

The inter-ambulacral areas are well developed (fig. 1 *a*, *d*, *f*), with two rows of tubercles, seven in each; those in the upper part of the area and at the ambitus are large, and at the base small; fig. 1 *f* shows one area magnified four diameters; the three pairs of large tubercles nearly occupy the entire surface of their respective plates (fig. 1 *i*); the boss has a wide base, surrounded by a well-defined areola, and this is encircled by a series of eight large mammillated granules; fig. 1 *i* shows one of these large plates, and fig. 1 *k* gives a profile of one tubercle with its surrounding granules, both figures are magnified six diameters; from the ambitus to the peristome the tubercles gradually diminish in size, and the four small basal nearest the mouth have a row of mammillated granules separating them from the poriferous zones (fig. 1 *f* and fig. 1 *h*). The miliary zone is wide, nearly of equal diameter throughout; and in addition to the large granules which form a series of crescents around the areolæ the interspace is covered with small granules sparsely strewed over the surface of the plates (fig. 1 *d*, *g*, *f*). The apical disc is large and prominent, consisting of a series of thick plates; fig. 1 *a* shows its natural size and relations, and fig. 1 *i* the same magnified four diameters. Three of the ovarial plates have an irregular hexagonal and two a rhomboidal figure (fig. 1 *b* and *e*); in all the oviductal holes are in the centre of the plates; the sur-anal plate is much thickened and raised to form the anterior wall of the periprocte (fig. 1 *a*, *b*, *d*, *e*); the ocular plates are triangular, having their base undulated and turned outwards: the outer border of both the ovarial and ocular plates are placed within the circle having its centre at the anterior wall of the vent; the sutures are well marked and punctated with small angular impressions; the vent is large and oblong (fig. 1 *b*, *e*), and the periprocte surrounded by a thick prominent annulus, which forms a conspicuous character of the test of this fine Salenia; the vent is excentral (fig. 1 *a*, *d*), and looks obliquely backwards and to the right side. The base is narrow, and highly ornamented; the small primary inter-ambulacral tubercles are closely set together, and the large mammillated ambulacral granules are very conspicuous, and form a prominent band between the tubercles (fig. 1 *c*, *h*); the miliary zone is wide, and filled with small close-set granules (fig. 1 *f*, *c*). The mouth-opening is oblong (fig. 1 *c*, *l*) about one third the diameter of the test. The peristome is decagonal, dividing the opening into ten unequal lobes; each of the ambulacral lobes, which are the largest, have a double crescentic outline, fig. 1 *h*, *l*: this is the only species of the genus *Salenia* which possesses an oblong mouth-opening, and this forms, therefore, one of the specific characters by which it is distinguished from its congeners.

Affinities and Differences.—This magnificent *Salenia* in point of size resembles *S. geometrica*, var. *Portlockii*, from the White Chalk. The test, however, is more elevated, the apical disc thicker and more prominent, and the inter-ambulacral areas resemble each other in the number and development of the tubercles in each row; the oblong vent and oblong mouth-opening are, however, special to *S. magnifica*.

Locality and Stratigraphical Position.—This Urchin was collected from the Upper Chalk near Norwich, and belongs to the British Museum collection.

Genus—Cottaldia, *Desor*, 1856.

Echinus, pars, *Kœnig*, 1820; *Münster*, 1826; *Forbes*, 1849. Arbacia, *Gray*, 1835. Cottaldia, *Desor*, 1856.

Test small, sub-globular, sides inflated, more or less depressed at the poles. Shell lobed, divided into fifteen sections; the five most prominent form the ambulacral, and the ten others, grouped in pairs, the inter-ambulacral areas. Poriferous zones narrow, straight; pores unigeminal. Tubercles small, mammillated, imperforated, uncrenulated, very numerous, homogeneous, and forming on each plate a close-set horizontal row. Granules microscopic, placed on all the inter-tubercular spaces. Apical disc solid, narrow, forming a prominent ring, composed of five perforated, rhomboidal, ovarial plates, and five cordate oculars; all the elements of the disc are covered with close-set granules. Mouth-opening moderate, lodged in a concave depression of the base; peristome sub-pentagonal, decagonal, and feebly notched.

The genus *Cottaldia* forms a very natural group of small fossil Urchins appertaining to the Cretaceous and Tertiary formations; well characterised by their sub-globular form, and the abundance and uniformity of their tubercles, arranged in horizontal series over the entire test. Much confusion formerly existed between Arbacia, *Gray;* Echinocidaris, *Desmoulins;* Polycyphus, *Agassiz;* and Magnosia, *Michelin*. This, however, has been in a great measure removed by clearer definitions of the genera retained, the suppression of those that were doubtful, and the establishment of the genus *Cottaldia*.

The uniformity of the tubercles, Prof. Desor remarks, attains its maximum in this small genus; and this character accords with its peristome, which is narrow and depressed, and its pores, which are unigeminal throughout the zones. These characters distinguish *Cottaldia* from the neighbouring types with which it has been confounded up to the present time. It is dedicated by M. Desor in honour of his friend M. Cotteau, the learned author of the 'Échinides fossiles de l'Yonne,' and of the 'Paléontologie Française.'

Cottaldia Benettiæ, *König*. Pl. XLV, figs. 1, 2, 3.

Echinus benettiæ,	*König*. Icones Foss. Sectiles, p. 2, pl. iii, fig. 35, 1825.
— granulosus,	*Münster*, Pet. Germ., p. 125, pl. xlix, fig. 5, *a. b*, 1826.
— —	*Grateloup*. Mém. Oursins Fossiles, Échinides, p. 82, 1836.
Arbacia granulosa,	*Agassiz*. Cat. Syst., p. 12.
— —	*Morris*. Cat. of British Fossils, p. 48, 1843.
— —	*Agassiz* et *Desor*. Cat. Rais. des Échinides, Ann. des Sc. Nat., 3rd series, vol vi, p. 356.
Echinus granulosus,	*Forbes*. Mem. Geol. Surv. Organic Remains, Decade I, pl. vi, 1849.
— —	*Forbes* in *Morris*. British Fossils, 2nd ed., p. 79, 1854.
Cottaldia granulosa,	*Desor*. Synop. des Échinid. Foss., p. 114, pl. xix, fig. 1—3, 1858.
— —	*Cotteau*. Paléontologie Française, Ter. Cretacé, t. vii, p. 789, pl. 1193 and 1194, 1—9, 1866.

Diagnosis.—Test small, globular, nearly equally depressed at both poles; plates of both areas very narrow, the inter-ambulacral supporting a horizontal series of small, equal-sized, imperforate, spiniferous tubercles, from eight to twelve in a row; the ambulacral tubercles of the same size, less numerous, and packed obliquely together; poriferous zones very narrow, pores unigeminal throughout; apical disc very small; mouth-opening large, placed in a depression; peristome slightly decagonal, notches feebly marked.

Dimensions.—Altitude, nine twentieths of an inch; latitude, six tenths of an inch; the relation of the altitude to the latitude varies considerably, some being more conical, others more depressed than others; in four specimens the ratio was 17 to 10, 15 to 11, 12 to 11, and 12 to 8.

Description.—This beautiful little Urchin was first figured by M. König in his 'Icones Fossilium Sectiles' under the name of *Echinus Benettiæ*, in honour of a lady who had long made the fossils of Wiltshire her especial study, and had published a valuable catalogue of the same; a year later the German forms of this species were figured and described in Goldfuss' 'Petrefacta Germaniæ' under Count Münster's name *Echinus granulosus*; subsequently it was entered in Agassiz and Desor's 'Catalogue Raisonné des Échinides' at the head of the list of their second type of *Arbaciæ* with uniform tubercles on all the surface of the test; and, lastly, M. Desor established the genus *Cottaldia* for this small group, which was characterised by having the surface of the small test covered with spiniferous tubercles, uniform in size and regular in arrangement,

forming distinct horizontal rows on the plates of the inter-ambulacra, and having the pores unigeminal throughout the narrow areas.

The test varies in form in different individuals from nearly a globular shape, as in Pl. XLV, fig. 1, to forms more or less depressed at both poles, as in figs. 2 and 3. The uniformity in size and arrangement of the numerous small tubercles covering the surface, and the division of the same into five broad and five narrow segments (fig. 1 *d*), by the poriferous zones radiating from the circumference of the apical disc (fig. 1 *b*) and converging below around the peristome (fig. 1 *c*), impart a remarkable physiognomy to this pretty little Urchin; the medial suture down the middle of the inter-ambulacra is often depressed, and then *Cottaldia Benettiæ* resembles a little melon, having its surface divided into fifteen lobes (fig. 1 *b*, *d*).

The ambulacral areas are about one third the width of the inter-ambulacral, and at the ambitus there are three or four tubercles on each plate (fig. 2 *b*), with numerous small granules around them; the outer rows of tubercles are the most persistent, and the inner rows in general are limited to the ambital region of the test; the poriferous zones are very narrow, and the pores numerous and unigeminal throughout (fig. 2 *b*); near the base they show a disposition to fall into triple oblique pairs, as in the genus *Echinus*, but the deviation is so slight that it is only occasionally seen in exceptional specimens; there are in general three pairs of holes opposite each ambulacral plate (fig. 1 *e* and fig. 2 *b*), so that in the specimen I am describing there are quite 100 pairs of holes in each zone.

The inter-ambulacral areas are three times as wide as the ambulacral; the plates are very narrow in proportion to their length, and in the specimen before me there are thirty-five plates in each column; each plate has a horizontal series of small equal-sized spiniferous tubercles; in the longest plates at the ambitus there are from nine to eleven on each according to the age and size of the specimen under examination; the tubercles of both areas are of the same size, but they are rather more closely set together, and more obliquely placed in consequence in the ambulacral areas (see fig. 1 *e* and fig. 2 *b*); the number of tubercles in each vertical row varies with the age and size of the specimen; they are most numerous near the ambital region; the rows nearest the poriferous zones are the longest and most persistent, and those near the miliary zone the shortest and most frequently absent. In some large specimens there is a depression in the line of the median suture in the inter-ambulacral areas, which gives this space a bilobed appearance; as these areas are nearly half the width of the ambulacral, the whole circumference of the test is divided by the five sutural depressions into ten poriferous zones and fifteen well-marked lobes, as represented in fig. 1 *a*, *b*, *c*, *d*, and this imparts a remarkable symmetrical neatness to the physiognomy of the Urchin.

The mouth-opening is nearly circular, and about one half the diameter of the test (fig. 1 *c*); the peristome, which is superficial, is very feebly notched opposite the zones.

The apical disc is a small ring-like structure slightly projecting from the surface of the test (fig. 1 *b*); the ovarial plates are sub-triangular (fig. 1 *b*), and perforated near

their outer third by a large oviductal hole; the madreporiform tubercle is feebly developed and occupies the inner portion of the right antero-lateral plate; in most specimens the ocular plates are small and angularly reniform, the orbit is excavated out of the centre of their outer margin, the elements of the disc are covered with numerous small granules, which are closely crowded together on the surface of all the plates.

The test is extremely thin, and the spines are at present unknown.

Affinities and Differences.—There are very few species in the genus *Cottaldia*. *C. conica*, Agass., is merely an elevated form of *C. granulosa*; *C. Buchii*, Steiniger, is a nearly allied species, from a Tertiary rock at Rommelsheim, near Früm.

Locality and Stratigraphical Position.—This Urchin was formerly very abundant in the Upper Greensand of Warminster, and at Chute Farm, Wilts. On the Continent the first-described specimens were collected at Regensburg, Bavaria. In France, according to M. Cotteau, it is found at Villers-sur-mer (Calvados); le Havre, Rouen (Seine-Inférieure); Vimoutiers, La Perrière (Orne); La Madeleine (Eure); le Mans, Coulaine, Yvré-l'Evêque, les Bordiers, Nogent-le-Bernard, Gavillé (Sarthe); Cherves-de-Cognac (Charente-Inférieure); La Bedoule (Var); very abundant in the Étage Cénomanien = Upper Greensand; Environs of Royan (Charente-Inférieure); very rare in the Étage Sénonien = Lower Chalk.

ECHINOIDEA EXOCYCLICA, *Wright*, 1855.

Before entering upon the study of the Echinoidea exocyclica, it is due to the Echinological student to state in general terms the reasons that have led to the adoption of names for several generic groups so different from those in general use at the present time. In working out the materials for these Monographs it has been my most earnest endeavour to do justice to my predecessors and contemporaries in the same field of labour, by observing the most scrupulous care in reference to priority of date in each genus and species founded on figures or descriptions, or both; without a rigorous base of equity on this fundamental principle, it would be vain to hope for the stability of any system of nomenclature, or limits to the interminable list of synonyms which would result from its neglect. In every case, therefore, I have traced back the history of each genus and species to its original author, and have added his name and the date after each, so that justice is done to every naturalist who has enriched our science by original work. The following remarks were made in the preface to my Monograph on the Oolitic

Echinodermata, and twenty years' experience has only afforded additional evidence of their truth.

"Many of the readers of this Monograph will probably be surprised to find some old generic names reproduced which have been long superseded by those of modern writers; but a sense of justice to such authors as Van Phelsum, Breynius, Klein, and Leske has led me to consult their original works and restore the genera first described and figured by them, but omitted from the treatises of later authors on the same subject.

"In the nomenclature of the *Echinodermata*, had I merely gone back to the time of Linnæus, as suggested by the Committee of the British Association in their Report made in 1842, I must necessarily have excluded the important work by Breynius,[1] in which, for the first time, were proposed seven well-described and accurately figured genera of *Echinoidea*, which, by some strange oversight, were not adopted by his contemporaries, although they have reappeared under new names in the works of later authors. On the principle of priority, therefore, I have restored the original genera so clearly defined by Breynius, even although it may occasion a temporary inconvenience in the names of some well-known forms of Urchins.

"In every case where practicable the name of the author who either first recorded, described, or figured the species follows the specific name of the object without the addition of 'Sp.' adopted by some authors. By this mode justice is done to the original author and confusion avoided. The modern practice of inventing new generic terms and appending to the old specific name that of the individual who has merely changed a word but discovered nothing cannot be sufficiently discountenanced, as it increases the confusion arising from an overloaded synonymy, and thereby retards the real progress of the natural-history sciences."[2]

The first author who described systematically and figured accurately many typical forms of *Echinidæ* was undoubtedly Breynius,[3] in his 'Schediasma de Echinis;' he takes the general form of the test and relative position of the vent as the basis of his methodical arrangement, in which he groups the whole order into the seven following genera.

I. *Genus*—Echinometra, *Breynius*, 1732.

Shell more or less globular, the mouth and vent occupying the two poles. This genus was retained by Gaultieri, 1742; by Seba, 1758, and by Van Phelsum, 1770; but it

[1] De Echinis et Echinitis, sive methodica Echinorum distributione, Schediasma. Gedani, 1732.

[2] 'Monograph on the British Fossil Echinodermata of the Oolitic Formation,' p. vii, Pal. Soc. vol. for 1855.

[3] Joannis Phillippi Breynii dissertatio physica de Polythalamiis—tandemque Schediasma de Echinis methodice disponendis cum figuris. Gedani, 1732.

was changed into *Cidaris* by Klein, in 1734, into *Echinus* by Linnæus, in 1758, and into *Echinus* and *Cidaris* by Lamarck in 1801, who suppressed the name *Echinometra* altogether. It has been restored to another group of Urchins by Agassiz in 1846, who unfortunately attributed the name to Klein instead of Breynius its author.

II. *Genus*—Echinoconus, *Breynius*, 1732.

The mouth in the centre of the base, and the vent beneath, at the margin, or above the border; the shell elevated, round, or conoidal. This generic name was ignored by Klein, 1734, who changed it to *Conulus;* Leske, his commentator in 1778, changed it to *Echinites.* Lamarck, 1801, omitted the names proposed by his predecessors, and gave that of *Galerites* to the same group; all the authors down to the time of Alcide d'Orbigny have followed Lamarck instead of Breynius, who nearly a century before had well described and figured this genus.

III. *Genus*—Echinocorys, *Breynius*, 1732.

The test is helmet-shaped, with the mouth and vent beneath, the former aperture before, and the latter at the marginal border. This generic name was ignored by Klein and changed by him to *Galea* in 1734. It was retained by Leske, 1778, by Parkinson, 1811, and Mantell, 1832. Lamarck in 1801 proposed the new name *Ananchytes* for this group, which was retained and adopted by all subsequent modern authors down to 1853, when d'Orbigny restored to this form Breynius' original name *Echinocorys.*

IV. *Genus*—Echinanthus, *Breynius*, 1732.

Large, oblong, shield-shaped Urchins with petaloidal, ambulacral areas, the mouth-opening beneath near the centre, and the vent within or below the marginal border; this genus was preserved by Gaultieri, 1742, and Leske, 1778. It was changed into *Scutum* by Klein, 1734; into *Clypeaster* by Lamarck, 1816; and into *Echinolampas* by Gray in 1834. Agassiz and most other modern authors retained the name *Echinolampas* until d'Orbigny rightly restored the old original name *Echinanthus* to all oblong Urchins with leaf-shaped ambulacra and the vent in the lower border.

V. *Genus*—Echinospatagus, *Breynius*, 1732.

Heart-shaped Urchins, with inflated sides, the ambulacra on the upper surface lodged in depressions of the test; the mouth anterior between the centre and the border; the vent on the upper part of the posterior border in a direction oblique to that of the mouth. This name was changed by Klein, 1734, to *Spatangus*, adopted by Lamarck and all subsequent authors. As the genus *Echinospatagus* represents a natural family rather than a genus, one of the forms figured by Breynius among his types ought to bear this generic name, whilst the other genera might be readily arranged around the central type form.

VI. *Genus*—Echinobrissus, *Breynius*, 1732.

Small buckler-shaped Urchins more or less depressed, the mouth-opening near the centre of the base, vent debouching into a deep dorsal sulcus, ambulacral areas petaloidal. The specimen figured as the type of this genus is one of the most common Oolitic forms. Still no author has cited this genus, and it appears to have been overlooked until Lamarck described it under the name *Nucleolites*.

VII. *Genus*—Echinodiscus, *Breynius*, 1732.

Discoidal Urchins with the mouth and vent opening near each other at the base. The ambulacra limited, petaloidal, and dorsal. Shell always flat; border thin, entire, or often indented or perforated. This genus was adopted by Gaultieri, 1742, and by Seba, 1758; by Leske and Davila, 1778. It was changed to *Rotula* by Klein, 1734, and into *Scutella* by Lamarck, 1801.

The 'Dissertatio Physica de Polythalamiis, de Belemnitis, de Echinis,' by Breynius, is a very scarce book. After endeavouring in vain to obtain it in commerce, I made known my want to my friend Professor de Koninck, of Liége, who kindly gave me the copy I now possess. In discussing many years ago the merits of this work with my old friend the Rev. Robert Hepworth, M.A., he kindly offered to make a translation for my Monograph of that portion of the dissertation which related to the classification of the *Echinodermata*, for which I heartily thank him, and I have now the pleasure of adding the version as it came from his pen. I have inserted such references to the plates of this Monograph as will help the reader to supply the absence of the original plates which accompany the work of Breynius.

"De Echinis et Echinitis, sive methodica Echinorum Distributione, Schediasma Joannis Philippi Breynii, M.D., et Societ. Reg. Lond. Sodalis."

"Genus I.—*The* Echinometra *is an Echinus with the oral aperture placed in the centre of the base, but with the anal one diametrically opposite at the summit.*

The term *Echinometra* occurs in Aristotle, who designates by it the largest genus of *Echini*. Naturalists dispute whether, on this point, regard must be had to the size of the spines, or of the test. Bellonius and his followers determine the latter. Hence I think that this name is not inappropriately affixed to this *Echinus*, since those belonging to this genus are found equal in size to an infant's head. There is this additional peculiarity, that this genus, among all the *Echini*, is provided with very large spines and tubercles. Its common name is *Ovarius*.

The *Echinometra* has many peculiarities which distinguish it from other *Echini*, besides the position of the apertures.

1. Internally there are five testaceous teeth, each elaborately composed of several parts, and surrounded by testaceous semicircles, which are situated internally around the oral aperture. Some species of *Echinanthus* are also furnished with teeth, but of a different structure.

2. The test is divided into five equal or nearly equal areas.

3. Externally it is rendered rough by tubercles, greater or smaller according to regular series, placed for the purpose of receiving the sockets of the spines; whilst in the other *Echini* all the tubercles are nearly equal in size and very small.

4. In like manner it has the primary and secondary spines more or less large and unequal in size, whilst all the spines of other *Echini* are very small, and generally of equal size.

5. I have also especially observed near the anal aperture a small warty substance [the madreporiform body], which can be more clearly distinguished with a lens, and similar to that which Linck first detected in the Star-fish, the use of which in that animal will doubtless throw light also upon this species of the *Echinometra*."

[Plates V and VI of this work represent typical forms of this group.]

"Genus II.—*The* Echinoconus *is an Echinus, whose apertures are both in the base, the oral in the centre, and the anal at or in the margin.*

It is either of a conical figure (the *Echinites pileatus* of Luidius), or hemispherical, or more or less compressed or oval. All of them have five duplicate pointed lines extending from the vertex to the oral aperture.

I have observed various fossil species of this genus, but only one recent species.

I have given it the name of Echinoconus from the conical figure which certain species possess.

Table II, fig. 1.—The Echinoconus verè conicus; perfectly conical, fossil; filled with cretaceous matter. From the Kent chalk pits. The *Echinites pileatus*, with either a conoid figure, or somewhat turbinated. [Plates XLIX and L of this work.]

Fig. 2. The base of the same, in which may be observed the oral aperture in the centre and the anal in the margin. [Plate L, fig. 1. *Echinoconus conicus*, Brey.]

Fig. 3. The Echinoconites hemisphæricus ferme, nearly hemispherical, consisting of siliceous matter, or of what is commonly called hornstone. [Plate LIII, fig. 2 *c*, *d*.]

Fig. 4. The base. [Plate LIII, fig. 2 *b*. *Echinoconus subrotundus*.]

Fig. 5. Echinoconus ovalis, the anal aperture near the margin. This is the only recent one known to me; it does not exceed half an inch in size, is fragile, and with a whitish shell.

Fig. 6. The base.

Genus III.—*The* Echinocorys *is an Echinus with both apertures in the base, the oral between the centre and the margin, and the anal as distant as possible from the mouth in the margin itself.*

All those which have come under my observation approximate in some measure in their form to that of a helmet. Hence they are termed by Luidius in his 'Lithophylacium Britannicum' *galeati* or helmeted.

I have designated the genus *Echinocorys* for the same reason, as Κόρυς among the Greeks signified a helmet or casque. Hitherto I have observed no recent specimen of this genus, but many fossil ones.

Table III, fig. 1. The Echinocorys vulgaris; fossil, filled with cretaceous matter, from the chalk pits near Gravesend, Kent. This is the common helmeted *Echinites* of Luidius.

Fig. 2. The base of the same, with two apertures; the upper one is the mouth, the lower the anus."

"Fig. 3. The ECHINOCORYTA, like marble, ashy grey, representing with the greatest exactness the internal face of the shell. [This is a siliceous mould of an *Echinoconus*.]

Fig. 4. The base. [Siliceous mould of the base of a small *Echinocorys vulgaris*.]

Genus IV.—*The* ECHINANTHUS *is an Echinus whose oral aperture is near the centre, and the anal upon or at that part of the margin which is at the greatest distance from the oral.*

All the species of this genus have an oval figure, one extremity of which is narrower, the other broader, in which latter the anal aperture is always situated; but the poriferous zones in the upper surface resemble a five-petaled flower, as though they were artificially marked by a needle; and for this reason I have assigned to this genus the name of *Echinanthus* or Urchin flower.

It is termed by Woodward *Echinus pentaphylloides, i. e.*, five-leaved, and is represented as having only one foramen in the centre of the base; whereas, on the contrary, the other foramen is conspicuous upon or at the margin in both the fossil and the recent species.

Fig. 1. The ECHINANTHUS, with the vertex (upper surface) more or less raised, of a whitish colour. From the Kleinian Museum. This species seems to approximate in the outward shape of an helmet to the *Echinocorys*, but it differs from it sufficiently in the position of the mouth, and in the likeness of the flower at the summit.

Fig. 2. The base. This fossil *Echinanthus*, filled with chalky matter, is depicted in the 'Museum Amboinæ,' Tab. LIX, fig. D.

Fig. 3. An *Echinanthus* of flatter form; fossil; filled with stony matter. From Monte Baldo, near Verona; remarkable for the upper surface with the anal aperture.

Fig. 4. An *Echinanthus* with the dorsal region more or less raised along its length; fossil; filled with stony matter of an ashy colour.

Fig. 5. The base. The oral aperture near the centre, the anal on the margin. In this genus the anal aperture is generally so situated that it can be viewed equally well from both the summit and the base. On this account I am the more astonished that Woodward should have overlooked it."

[Plate LVIII, *Pygurus lampas*, represents a type form of this genus.]

"Genus V.—The ECHINOSPATAGUS *is an Echinus whose oral aperture is between the centre and the margin, but the anal is situated obliquely opposite to the mouth upon or at the margin towards the summit.*

The figure is usually heart-shaped, the furrow being on the upper surface at the broader extremity; or it is oval without a furrow of that kind. But the anal aperture is always observable in the narrow extremity, as in the *Echinanthus*. In some species there is also, it appears, some representation of a flower, as in my *Echinanthus*, but this consists not of *five* but of only *four* petals, and those of unequal size; the fifth towards the broader extremity being absent.

I have thought that the name of *Spatagus* or *Spatangus*, derived from the Greek Σπάταγγος, and which is found in Aristotle and other naturalists who have thus designated this *Echinus*, ought, on this account, to be retained, although more recent writers have extended the term *Spatagus* or *Spatangus* to *all* except the oval *Echini;* and these Woodward also has followed in his catalogue, which embraces under this title all except the oval and those marked with five leaves—the pentaphylloidal shaped.

Table V, fig. 1.—The ECHINOSPATAGUS CORDIFORMIS; very common. The anal aperture which, in the entire shell, is usually closed because it is membranous, does not seem to be less minute than in the oval. I have found the shells of this genus empty, blanched, and very fragile. They are very commonly found on the shores of the Adriatic, near Pesaro, where they are termed *Cuglioni* on account of their shape and size.

Fig. 2. The base, in which may be observed both the oral aperture and the anal one of less size.

Fig. 3. The heart-shaped *Echinospatagus*, more or less flat, of a smaller size; fossil; filled with chalk rock; from, I believe, Wirtemberg. Fig. 4. The base.

Fig. 5. The heart-shaped *Echinospatagus;* fossil. English, from the Kent chalk pits. The *Echinites cordatus* of Luidius. [See Plate LXII, *Micraster cor-anguinum.*]

Fig. 6. The base. [Plate LXII, fig. 1 *b.*]

Genus VI.—*The* ECHINOBRISSUS *is an Echinus whose oral aperture usually occupies the centre of the base, but the anal is seen upon the upper surface at a short distance from the centre, and in a furrow obliquely opposite to the mouth.*

It is always of an oval shape, with the mouth invariably placed towards the narrower and the anus towards the broader part. Some species are rather more elevated, and represent in some measure the human buttocks; hence it is called *clunicularis* by Luidius:

but others with a flatter surface may be compared to a shield; hence they are termed *Echini clypeati.*

The *Brissus* (Βρίσσος) is enumerated by Aristotle in his fifth book of the 'History of Animals' as the *third* genus of *Echini.* But since his translators have not sanctioned what this naturalist understood by that term, I have applied the name of *Brissus* to this genus.

No recent *Echinobrissus* has come under my observation, but I have seen some fossil species, although these latter are by no means common. Morton assigns only one aperture to this *Echinus,* since the other situated in the furrow escaped his notice; but Woodward ought afterwards to have discovered it, since he enumerates it among the *Echini* which have two apertures, the other being in the furrow.

Table VI, fig. 1. The ECHINOBRISSUS PLANIOR or CLYPEATUS MINIMUS; fossil; filled with stony matter; with the anal aperture in the furrow. From England. [*Echinobrissus clunicularis.*]

Fig. 2. The base with the oral aperture.

Fig. 3. ECHINOBRISSUS ELATIOR; more or less raised; fossil; filled with stony matter. From England. [*Echinobrissus scutatus,* a characteristic fossil of the Coralline Oolite.]

[Plate LVI, figs. 1 and 2 represent several type forms of *Echinobrissi* from the Cretaceous formations. This genus has one living representative species.]

Genus VII.—*The* ECHINODISCUS *is an Echinus with the oral aperture situated near the centre, but with the anal between the centre and the margin or on the margin. The form always somewhat flattened.*

All the species of this genus have the likeness of a five-leaved flower upon the upper surface.

I have termed it *Echinodiscus* from the figure of a disc or orb.

As I have not seen any recent *Echinus* of the genus immediately preceding, so, on the other hand, I have never hitherto observed a fossil of this genus. The following species were all brought from the Eastern Ocean.

Table VII, fig. 1. The ECHINODISCUS CIRCINATUS MINOR, with the margin entire.

Fig. 2. The base or lower portion, in which is seen the anal aperture, but the other (the oral) in the middle is not visible on account of the mutilation of the shell in the centre.

Fig. 3. *Echinodiscus,* one half of the circumference generally marked with equal indentations.

Fig. 4. The base, in which are seen the oral and anal apertures."

"Fig. 5. All *Echinodiscus*, one half of the circumference marked with unequal indentations. The other half furnished with two pervious apertures.

Fig. 6. The base, with mouth and anus.

Fig. 7. The ECHINODISCUS MAXIMUS, with margin entire. The anal aperture placed on the margin itself. From the Kleinian Museum.

Fig. 8. The base, with the oral aperture in the centre.

A new genus may not inaptly be constituted as the eighth in order in my 'System,' from this last species, since it differs as to the rule of the position of the anal aperture, and in the absence of the representation of the flower. But since only this single species has been known hitherto, I have preferred adding it to the *Echinodisci*, until perchance some other specimen shall have been discovered."

[I must refer all interested in the study of this group to Professor L. Agassiz's admirable Monograph 'Des Scutelles,' with magnificent plates of living and fossil forms. T. W.]

VI. *Family*—ECHINOCONIDÆ, *Wright*, 1854.

When I proposed the establishment of this Family I defined it as a natural group of fossil *Echinoidea* having a thin, circular, or slightly pentagonal test; the upper surface in most of the forms being very much elevated or conoidal, in others it is more or less depressed.

The ambulacral areas are narrow and the inter-ambulacral wide; the plates of both are covered with numerous, small, perforated tubercles, raised on bosses with crenulated summits. They are sometimes scattered over the plate, but are frequently arranged in regular longitudinal rows. They are always larger at the base than on the sides and dorsum; and the surface of the test is likewise covered with close-set microscopic granules.

The poriferous zones are narrow, and formed throughout of round unigeminal pores about equal in diameter; they converge in a straight line from the apical disc to the peristome, around which aperture they have sometimes a bigeminal arrangement.

The mouth-opening is inferior, central, sub-circular, and armed with five pairs of jaws; the peristome is more or less decagonal and divided by notches into ten lobes, well marked in *Pygaster* and *Holectypus*, but feebly in *Discoidea* and *Echinoconus*.

The vent is variable in position; it is situated at the upper surface in *Pygaster*, at the border in *Echinoconus*, at the base in *Discoidea*; and this aperture is oval, pyriform, or oblique in different genera.

The apical disc occupies the summit of the upper surface, and is composed of five ovarial and five ocular plates; the madreporiform body is very large, extending from the right antero-lateral ovarial into the centre of the disc.

The posterior ovarial is often replaced by a complementary, imperforate plate, which is sometimes wanting altogether.

The spines are small, short, and subulate.

The ECHINOCONIDÆ are distinguished from the ECHINOBRISSIDÆ, ECHINOLAMPIDÆ, and CLYPEASTERIDÆ, by their simple poriferous zones; in this respect the family resembles the ECHINONIDÆ, from which, however, it differs in possessing a peristome furnished with auricles and a masticating apparatus; the form is likewise more circular and elevated, and the tubercles are more developed and arranged in longitudinal rows.

The ECHINOCONIDÆ are an extinct family, found only in the Oolitic and Cretaceous rocks; at present we recognise six well-defined genera in this natural group, which present the following opposite characters:

Test elevated; ambitus with projecting internal septa; vent inferior always	DISCOIDEA.
Test elevated; peristome sub-decagonal; vent marginal .	ECHINOCONUS.
Test depressed; ambitus without internal septa; vent inferior and marginal	HOLECTYPUS.
Test depressed; peristome decagonal; vent oblique, distant from the disc; tubercles perforated and crenulated . .	ANORTHOPYGUS.
Test depressed; peristome decagonal; vent pyriform, separated from the disc; tubercles perforated, but not crenulated; irregularly superposed pores . . .	PILEUS.
Test depressed; peristome decagonal; vent pyriform, not separated from the disc; tubercles perforated and not crenulated; pores unigeminal, regularly superposed . . .	PYGASTER.

I. *Genus*—DISCOIDEA, *Klein*, 1734.

GALERITES, pars, *Lamarck*, 1801. DISCOIDEA, *Gray*, 1834. DISCOIDEA, *Agassiz*, 1836. DISCOIDEA, *Desor*, 1842.

Test circular or subpentagonal at the border; upper surface much elevated, hemispherical; sides vertical or slightly convex; inferior surface flat, slightly concave.

Poriferous zones very narrow, and converging in a straight line from the disc to the peristome.

Tubercles very small, perforated, crenulated, and surrounded by areolæ, unequal and microscopic on the sides and upper surface; larger at the ambitus and base, and disposed there in regular concentric rows.

Mouth-opening small, circular, central; peristome decagonal, marked by slight notches.

Vent inferior, oval, sub-acuminate at both extremities, situated between the peristome and posterior border; opening covered with irregular granular plates, which are very small around the anal opening; this aperture is placed near the internal angle.

The apical disc solid, well soldered to the areal plates, and forming a slight projection above the test, having in some five perforated ovarial plates, in others four perforated ovarials, and an imperforate, complementary, single ovarial; madreporiform body resting on the larger antero-lateral, and extending into the centre of the disc; ocular plates small and well wedged into the angles of the ovarials.

From the inner surface of the inter-ambulacral plates near the poriferous zones thick shelly processes project inwards, and form internal septa, which occasion the ten characteristic impressions near the ambitus seen on the moulds of this genus.

Spines short, stout.

The *Discoidea* very much resemble *Holectypus*. Prof. Desor properly separated the latter from the former in consequence of the absence of all internal ribs from the shell of *Holectypus*, which likewise has a larger mouth-opening, the peristome deeper notched, and the vent often marginal.

A.—*Species from the Upper Greensand.*

DISCOIDEA SUBUCULUS, *Klein*, 1734. Plate XLV, figs. 4, 5, 6.

DISCOIDES SUBUCULUA,	*Klein.* Nat. dispositio Echinodermatum, p. 26, pl. xiv, *l*, *m*, 1734.
ECHINITES SUBUCULUS,	*Leske*, apud Klein, p. 171, pl. xiv, *l*, *m*, *n*, *o*, 1778.
— —	*Gmelin.* Systema Natura, p. 3183, 1789.
— —	Encyclop. méthod., Moll. et Zoophyt. Atlas, pl. 158, figs. 14, 15, 1791.
DISCOIDEA SUBUCULUS,	*Parkinson.* Organic Remains, vol. iii, p. 21, 1811.
ECHINITES,	*Smith.* Strata Ident. by Organ. Foss., pl. vii, fig. 12, 1816.
GALERITES ROTULARIS,	*Lamarck.* Animaux sans Vert., t. iii, p. 21, 1811.
— —	*Deslongchamps.* Zooph., Encyl. méthod., t. ii, p. 433, 1824.
— —	*Defrance.* Galerites, Dic. Sc. Nat., t. xviii, p. 86, 1825.
GALERITES SUBUCULUS,	*Goldfuss.* Petref. Germaniæ, t. i, p. 129, pl. xlix, fig. 2, 1826.
ECHINONEUS ROTULARIS,	*Blainville.* Zooph., Dic. Sc. Nat., t. lx, p. 194, 1830.
DISCOIDEA SUBUCULUS,	*Bronn.* Lethæa Geogn., p. 615, pl. xxix, fig. 19, 1835.
— ROTULARIS,	*Agassiz.* Prodrome d'une Monogr., p. 186, 1836.

Galerites hemisphæricus,	*Grateloup.* Mém. les Oursins Fossiles, p. 55, 1836.
— subuculus,	*Desmoulins.* Études sur les Échinides, p. 254, 1836.
Discoidea subuculus,	*Desor.* Monogr. des Galerites, p. 54, pl. vii, figs. 5—7, 1842.
— —	*Morris.* Catalogue of British Fossils, p. 52, 1843.
— —	*Agassiz* and *Desor.* Catal. rais. des Éch., Ann. Sc. Nat. 3e série, t. vii, p. 146, 1847.
— —	*A. Gras.* Oursins fossiles de l'Isère, p. 44, 1848.
— —	*Bronn.* Index Palæontologicus, p. 430, 1848.
Galerites subuculus,	*Forbes.* Mem. Geol. Surv., Dec. 1, pl. vii, 1849.
Discoidea subuculus,	*d'Orbigny.* Prod. de Pal. Strat., t. ii, p. 179, 1850.
— —	*Sorignet.* Oursins fossiles de l'Eure, p. 39, 1850.
Galerites subuculus,	*Forbes* in Dixon's Geology of Sussex, p. 341, 1852.
Discoidea subuculus,	*Forbes* in Morris's Catalogue of Brit. Fossils, 2nd ed., p. 77, 1854.
— —	*Desor.* Synop des Échinides Foss., p. 176, pl. xxiv, fig. 1, 1857.
— —	*Cotteau* and *Triger.* Échinides Foss. de la Sarthe, p. 170, pl. xxiv, fig. 12, 1859.
— —	*Cotteau.* Paléontologie Française, Ter. Crétacé, t. vii, p. 23, pl. 1009, fig. 8—16, 1864.
— —	*De Loriol.* Oursins de la Suisse, pl. xiii, fig. 15, 1873.

Diagnosis.—Test small, circular, or slightly pentagonal; upper surface inflated, more or less conical; under surface concave in the middle; ambulacra forming five prominent bands, composed of very narrow plates; poriferous zones narrow, straight, holes unigeminal in oblique pairs. Interambulacra wide, divided into three lobes by two subcentral carinæ, which rise from near the middle of the plates; miliary zone concave, depressed; tubercles small, perforated, larger at the base; on the sides there are two regular, constant, carinal rows, and eight or ten less regular and inconstant; at the base the principal tubercles are arranged in concentric lines around the peristome. Surface of all the plates covered with fine close-set granulations; mouth-opening small, sunk in the middle of a deep depression; vent infra-marginal, pyriform, midway between the peristome and border, with the apex directed inwards. Apical disc small, prominent, composed of five ovarial and five very small ocular plates.

Dimensions.—Height, seven twentieths of an inch; latitude, eleven twentieths of an inch. The relative proportion of height to breadth varies considerably in different specimens.

Description.—A figure given by Plott[1] in his 'History of Oxfordshire,' pl. viii, fig. 9, and described as "another sort of Button-stone, sent me from Teynton, which I take to be a mere production of nature, finely striated from the top, as I have seen some hair buttons, as in Fig. 9, and may therefore be called *Porpites:* except we should rather take it for a new sort of *Echinites* not yet discovered, which is wholly left to the reader's choice." Martin

[1] 'The Natural History of Oxfordshire,' ed. 1677, pl. viii, fig. 9, p. 139.

Lister[1] in his 'Hist. Animal. Angliæ' states, in reference to his fig. 20, tab. vii, which is copied from Plott, "Echinites parvulus striis capillaceis undiq; insignitus," ex D. Plott, fig. 9, tab. viii, "Juxta Teynton agri Oxoniensis inventus est."

Lang,[2] in his 'Historia Lapidum Figuratorum,' says, in reference to "Echinites, striis capillaceis à centro ad circumferentiam undique insignitus, subluteus mediocris rotundus, vertice compresso, basi ex pluribus annulis striatis sibi invicem impositis conflatà." I regard the original of Plott's figure not as an Echinite, but as a species of Coral belonging to the family Cyclolitidæ, genus *Anabacia;* about Lang's figure I think there can be no doubt, the concentric ridges of the epitheca at the base afford sufficient evidence of the class Anthozoa to which his fossil Coral belonged. Klein's 'Naturalis Dispositio' is the first work[3] in which we find an undeniable figure of this Urchin; in tab. xiv, *l, m, n, o,* he says, "*Discoides subuculus;* Kamisol-Knopff: Discum Germanorum imitans, si versum vel supinum consideramus, *a Vertice rosaceo;* quinque seriebus geminis capillaceis et velut acu pictis; in vertice figuram rosulæ ferens." Leske,[4] in his 'Additamenta ad Kleinii Echinodermata,' observes, in reference to the figure given by Plott and Lister, "pro Echinite exhibetur; at vero quantum ex icone coniicere licet, potius Madreporites est, quam Echinites. Nam striæ capillaceæ ex centro progrediuntur, ut in Madreporis, neque aliqua oris vel ani mentio fit, præterea a Plotio *Porpites* dicitur, quod ipsum nomen *Madreporis* petrefactis tribui solet. Tanquam dubium corpus, illud itaque omisi." Of Lang's figure Leske says, "mea sententia firma manet, hæc corpora non Echinitas, sed Madreporitas esse."

The figures of this Urchin given by Parkinson of English specimens, and by Brongniart of French, are very poor; and those of Bronn and Goldfuss of German forms, are not satisfactory. The first real good drawing is that given by Professor Desor in his valuable 'Monograph on the Galerites,' and since then Professor E. Forbes' beautiful plate of this species in the 'Memoirs of the Geological Survey,' decade 1, pl. vii, leaves nothing to be desired; subsequently admirable figures have been published in the 'Paléontologie Française, Terrain Crétacé,' and in the Échinides of the department of the Sarthe, by M. Cotteau.

The test is small, orbicular, or slightly pentagonal, the upper surface convex, more or less conical, and divided into five broad and five narrow segments by the poriferous zones, which radiate with mathematical accuracy from the circumference of the apical disc, which is small and prominent at the vertex. The under surface is rounded in young and concave in adult specimens, the small, circular mouth-opening lies in a deep central depression, and between it and the posterior margin is a large oblong vent.

The inter-ambulacral areas at the ambitus are nearly twice the width of the ambulacral; the dorsal surface of large specimens contains thirteen plates in each column between the apical disc and the basal angle; the length of the plate varies from the ambitus, where

[1] 'Historia Animalium Angliæ,' 1678, tab. vii, fig. 20, p. 220.

[2] 'Historia Lapidum Figuratorum Helvetiæ,' 1708, tab. 36, figs. 1, 2, p. 126.

[3] 'Naturalis Dispositio Echinodermatum,' 1734, tab. xiv, sec. 57, p. 26.

[4] Ibid., Additamenta ad Kleinii, 1778, p. 172.

they are longest, to the apex, where they are shortest, but their vertical depth is nearly the same throughout; their surface is thickly covered with minute secondary granules placed in very regular horizontal rows (fig. 4 *g*). Each plate exhibits a more or less distinct sub-central carination, so that in many specimens the inter-ambulacral areas appear to be partitioned by two prominent ridges on each side of the line of junction of the plates. Along the carinated ridge each plate develops a larger tubercle, and these form a complete series from the base to the summit (figs. 4, *a*, *b*, *d*, *g*): between this and the median suture there are two smaller tubercles placed horizontally (fig. 4 *g*), and between the carina and the poriferous zones are two or more similar tubercles placed in two oblique series with reference to the larger central tubercles on the line of carination; consequently the primary tubercles placed between the carinated ridge and the median suture are horizontal, and those between the ridge and the zones arranged in oblique rows (fig. 4). At the ambitus the tubercles are more numerous and less regularly disposed. The basal plates resemble very much those on the upper surface; in full-grown specimens they are from six to eight in number; they are of the same vertical depth as those on the dorsal surface, and are ornamented in a like manner.

The ambulacral areas are half the width of the inter-ambulacral; the plates are numerous and narrow, four plates occupying the vertical depth of one inter-ambulacral plate (fig. 4 *g*); they are closely covered with small granulets, and each plate supports a small primary tubercle. These tubercles are so placed that they form oblique rows of twos or threes, and do not form direct vertical rows. The plates forming the ventral portion of the areas are rather larger than those on the dorsal surface (fig. 4 *c*).

The poriferous zones are straight and extremely narrow; the pores are unigeminal, and the pores of each pair are obliquely placed (fig. 4 *h*, *g*). Each inter-ambulacral column contains twenty-one plates, and each ambulacral column eighty-four, and there are one pair of pores opposite each plate; it follows that each zone contains eighty-four pairs of pores; all the primary tubercles are raised on elevated bosses in areolar spaces, and they are all perforated (figs. 4 *f*, *g*, *h*).

The apical disc is small, and makes a slight prominence at the vertex; the right antero-lateral plate is the largest, and supports a large madreporiform body (fig. 4 *c*); the single ovarian plate is imperforate, as in all its congeners. The ocular plates are very small, and closely fitted in between the ovarials.

The mouth is circular, and occupies a deep depression in the centre of the under surface; it is about one fourth the diameter of the base; the peristome is feebly decagonal, and the lobes are nearly equal (fig. 4 *c*).

The vent occupies a considerable portion of the basal region in the single inter-ambulacrum, between the peristome and the border; it is of a pyriform shape, having its small extremity directed inwards towards the mouth with a series of tubercles surrounding it (fig. 4 *c*).

Like other *Discoideæ*, moulds of the interior differ materially from the external shape

of the test in exhibiting ten notches around the margin, extending to the mouth on the ventral surface, and disappearing at the lower third of the dorsal. Five of these unite near the mouth, and five continue singly to it. The centre of the prominent interspaces of the latter is marked by a shallow depression. This groove corresponds to the line of suture of the ambulacral plates, and its prominent sides to the pores. The ten deep notches are caused by as many internal ribs, which spring from the inner sides of the mouth, and run up the wall under the carinated portion of each series of inter-ambulacral plates."—*Forbes.*

Affinities and Differences.—After a careful comparison of *D. subuculus* with the four following allied species, the late Professor Forbes remarks :[1]—The first, *Discoidea minima*, Agass., founded on a single example from the Chalk-marl of France, appears to be only one of the less conical forms of the young of the species, such as not uncommonly occur at Warminster. The second, *D. pisum*, Merian, is said to be exactly like *D. minima*, and only distinguishable from it and *D. subuculus* by having distinctly perforate primary tubercles; this, however, is a generic and not a specific character. The third, *D. turrita*, Desor, is proportionally higher than *D. subuculus*. The fourth, *D. infera*, Desor, has primary tubercles only at the base. I have little doubt, the Professor observes, that the several so-called species just enumerated are only slight varieties, if as much, of *D. subuculus*. M. Cotteau admits that *D. pisum* may be the young of *D. subuculus*, but that the three others indicated by Professor Forbes are certainly distinct. *D. subuculus* differs from *D. Dixoni*, Forb., in having smaller mouth- and vent-openings, so that the appearance of the base is materially different.

Locality and Stratigraphical Position.—This Urchin is abundant in the Upper Greensand of Warminster, and Chute Farm, Wilts; in the junction beds of Greensand and Chalk-marl at Maiden Bradley, Wilts; the Lower Chalk at Weymouth, and the Grey Chalk near Folkestone. This species is very abundant in the different type localities of the Étage Cénomanien in France, see p. 189.

B.—*Species from the Lower Chalk.*

DISCOIDEA CYLINDRICA, *Lamarck's* sp. Pl. XLVI, figs. 1, 2; Pl. XLVII, figs. 1—3.

GALERITES CYLINDRICUS,	*Lamarck.* Animaux sans Vertèbres, tom. iii, p. 23, 1816.
— —	*Deslongchamps.* Encycl. Méthod., Zoophytes, t. ii, p. 433, 1824.
CONULUS HAWKINSII,	*Mantell.* Geol. Trans., new series, vol. iii, part I, p. 208, 1828.
GALERITES CANALICULATUS,	*Goldfuss.* Petrefacta Germaniæ, vol. i, p. 128, pl. xli, 1829.

[1] 'Memoirs of the Geological Survey,' Decade 1, pl. vii, p. 4.

SCUTELLA DEPRESSA,	*Woodward.* Geology of Norfolk, p. 52, pl. v, fig. 4, 1833.
— HEMISPHERICA,	*Woodward.* Idem, pl. v, fig. 5, 1833.
DISCOIDEA CANALICULATA,	*Agassiz.* Prodrome, Mém. Sc. Nat. Neuchatel, t. i, p. 186, 1836.
GALERITES HAWKINSII,	*Desmoulins.* Études sur les Échinides, p. 254, 1837.
DISCOIDEA CYLINDRICA,	*Agassiz.* Échinid. foss. de la Suisse, Part I, p. 92, pl. vi, figs. 13—15, 1839.
GALERITES CYLINDRICUS,	*Dujardin.* Animaux sans Vertèbres 2e ed., t. iii, p. 311, 1840.
DISCOIDEA CYLINDRICA,	*Desor.* Monographie des Galerites, pl. viii, figs. 8—16, p. 58, 1840.
— —	*Morris.* Catalogue of British Fossils, p. 52, 1843.
— HEMISPHÆRICA,	*Morris.* Idem.
— CYLINDRICA,	*Agassiz* et *Desor.* Catal. rais. les Éch. An Sc. Nat. 3e ser., t. vii, p. 147, 1847.
— —	*Bronn.* Index Palæontologicus, p. 429, 1848.
GALERITES (DISCOIDEA) CYLINDRICUS,	*Forbes.* Mem. of Geol. Surv., Decade 1, pl. viii, 1849.
DISCOIDEA CYLINDRICA,	*d'Orbigny.* Prod. de Pal. strat., t. ii, p. 178, 1850.
GALERITES CYLINDRICUS,	*Quenstedt.* Hand. der Petrefact., pl. xl, fig. 20, p. 583, 1852.
DISCOIDEA CYLINDRICA,	*Gras.* Catal. Ours. foss. de l'Isère, p. 43, 1852.
— —	*Morris.* Catal. Brit. Foss., 2 ed., p. 77, 1854.
— —	*Pictet.* Traité de Paléont., t. iv, p. 228, pl. xcv, figs. 9—12, 1857.
— —	*Desor.* Synopsis des Échinides Fossiles, p. 177, pl. xxix, fig. 12, 1857.
— —	*Cotteau.* Paléont. Française, Ter. Cret., t. vii, p. 28, pl. 1010 et 1011, 1866.
— —	*De Loriol.* Ours. de la Suisse, pl. xiii, fig. 14, 1873.

Diagnosis.—Test large, sub-circular, slightly pentagonal; upper surface hemispherical, more or less elevated, regularly convex above, rounded vertically on the sides, and acutely angular at the border; base nearly flat, marked by impressions which correspond to the internal carina; ambulacra one third the width of inter-ambulacra; mouth-opening central, decagonal; vent small, oblong, basal, midway between the peristome and border.

Dimensions.—A. Height, one inch and four tenths; latitude, two inches and one tenth.

B. Height, one inch and eight tenths; latitude, two inches and two tenths.

Description.—Whether this common Chalk Urchin was known to Leske or not is difficult to decide. My friend Professor Desor considers the notice on *Echinus quaterfasciatus* to refer to this species; but a careful examination of Leske's figures leads me to the conclusion that the mouth figured by that author in his Pl. xlvii represents some species of the genus *Echinoconus* rather than a *Discoidea*, for they show no trace of

impressions made by the internal ribs, so characteristic of the latter genus. For this reason I am of opinion that the history of this Urchin commences with Lamarck's description.

The outline of *Discoidea cylindrica* is orbicular, the base is very flat, and the upper surface convex, more or less elevated, the amount varying with its phases of growth from a regularly hemispherical form in young shells, as in the specimen figured in Pl. XLVI, fig. 2 *a*, to hemispherico-cylindrical, its adult condition, as shown in Pl. XLVI, fig. 1 *c*, and Pl. XLVII, fig. 1 *a*, *b*.

The inter-ambulacral areas are three times the width of the ambulacral (fig. 1 *a*, *b*, *d*); the plates on the sides and lower part of the dorsal surface are broad horizontally and narrow vertically (fig. 1 *d*), and those around the vertex are nearly square (fig. 1 *e*); near the middle of each plate there is a slight elevation of the surface which, in connection with others in the column of plates, form a line of carination, which extends from the apical disc to the circumference, and imparts a marked feature to some old tests (Pl. XLVII, fig. 1). On this ridge a tubercle rather larger than the others is developed (fig. 1 *d*) on the lower half of each plate; (this tubercle with the line of carination is indicated in fig. 1 *d* by the vertical shading). On the surface of each plate from the sides of the test there are from six to seven larger, and the same number of smaller tubercles (fig. 1 *d*), all of which are perforated and striated, and their areolar spaces surrounded by circles of minute granules (fig. 2 *d*); the quadrate plates in the upper portion of the columns support only the one tubercle growing on the line of carinations already referred to (fig. 1 *e*). In addition to the perforated and striated tubercles, the plates are covered with microscopic granules, distributed very regularly over the surface. The series of plates around the angular border are narrow, and bear five or six large tubercles arranged in regular horizontal rows, having areolar excavations around their base. Those on the basal plates are still more conspicuously ornamented with rows of primary tubercles, each surrounded by a depressed areola bounded by granules, which are larger and more thickly set than on the upper surface. The plates round the mouth are smaller and have fewer tubercles (fig. 1 *b*). The inferior inter-ambulacral plates bulge out on each half near the margin, a prominence which is continuous with the lines of carination above, and indicates the position of the internal ribs in the interior of the test. Pl. XLVII, fig. 2 *a*, *b*, shows the position of impressions made by the internal ribs on a well-marked mould; from this we learn that the two impressions at the base of each inter-ambulacra, and the ridge at the circumference, are due in part to the internal ribs of the test.

The ambulacral areas are narrow and lanceolate above, and of the same width and more prominent at the base; they are composed of small unequal plates, of which about three correspond vertically to one inter-ambulacral plate. They are, however, very irregular in size and shape, some being narrow, others rhomboidal or triangular, with small wedge-shaped pieces fitted into the poriferous zones, the whole forming a kind of mosaic of many-sized pieces. The plates at the base and on the upper surface are more regular in form and smaller in size than those on the sides (fig. 1 *d*); each plate carries

one or two small primary tubercles; at every third plate one of these is near the zonal side (fig. 2 *f*), so that in each ambulacra there are two marginal rows of small perforated and crenulated tubercles surrounded by several microscopic granules.

The poriferous zones are very narrow, and have one pair of small round holes opposite each ambulacral plate, which are larger and more conspicuous on the dorsal than on the ventral surface; on the lateral and dorsal surfaces the pores are unigeminal, but at the base, from the narrowness of the plates, they fall into double file (fig. 2 *f*), and near the mouth-opening two rows go to each plate, the number of pairs of pores corresponding with the number of the ambulacral plates; taking the average as equal to seven ambulacral plates for two inter-ambulacral an average-sized adult test would have seventy pairs of pores in the lateral and dorsal portions of the zones; the exact number at the base it would be difficult to estimate, from the narrowness of the plates and the bigeminal arrangement of the pores.

The base is flat and the mouth-opening occupies the centre of the disc; it is a small obscurely decagonal opening (Pl. XLVI, figs. 1 *b*, 2 *b*), equal in diameter to one fourth the distance between it and the border; the peristome is subcircular and divided into ten equal lobes; it is only in some rare specimens that this part of the anatomy of the test is shown, as the oral opening is nearly always filled with closely adhering matrix. In some fine specimens from the soft Grey Chalk I have been able to clear out the peristome and demonstrate the oral lobes.

The vent is proportionately very small, oblong, and acute at each extremity. It occupies rather more than one fourth of the space between the mouth and border, and is distant from the margin about its own long diameter (fig. 1 *b*). The plates of the single inter-ambulacrum appear sharply incised by the vent, the margins of which are on a level with them except at the inner extremity, where there is a bulging of the plates extending to the peristome (Pl. XLVII, fig. 1 *b*).

The apical disc is well shown in my type-specimen; and this structure is accurately drawn in Pl. XLVI, fig. 2 *c*. It is often prominent in consequence of the convexity of its elements; the five ovarial plates are of an irregular rhomboidal figure and closely united together; four of the five plates are perforated for the passage of the genital tubes, the single plate is imperforate, and the microscopic madreporiform body occupies the entire surface of the right antero-lateral plate. The five ocular plates, each having an orbit, are small cordate bodies wedged into the angles of the ovarials, fig. 2 *c* shows this structure magnified six diameters. Mr. Bones' very accurate drawing renders any lengthened description of the discal elements unnecessary.

In Pl. XLVII, fig. 2 *a*, *b*, I have figured a very perfect mould of this Urchin to assist the geologist to identify the species when all the test is absent. This mould is marked by ten impressions made by the internal carinæ of the test, which deeply groove the border and base and extend from the lower part of the sides, pass along the floor of the test and vanish at the peristome. In addition to these well-marked depressions Professor

Desor describes and figures three fine marginal incisions visible below and in profile in each column of plates, and which assume a different form in the single inter-ambulacrum where they are only two in each column; they are here wider and deeper than those in the pairs of the inter-ambulacra.

Pl. XLVII, fig. 3, is the drawing of the base of a mould of a monstrosity of this species, in which there are only four ambulacra seen from below.

Affinities and Differences.—*Discoidea cylindrica* cannot be mistaken for any of its congeners, as it is readily identified by its great height, its inflated and sub-cylindrical form, its perfectly flat base, and by the proportionate smallness of the oral opening and the vent. *Discoidea Favrina* is the nearest allied form; this, however, differs from *D. cylindrica* in having a larger vent placed nearer the border, and in having the inter-ambulacral plates much larger; each plate, in vertical height, corresponding to six ambulacral plates.

Locality and Stratigraphical Position.—This species occurs in the Upper Chalk of Norwich and Holt (Mr. S. Woodward, Sen.), Chalk Marl and Lower Chalk at Hamsey, near Guildford, Markham Gayton, Charing, Lewes, Dover, Burham, near Maidstone, Speeton, Yorkshire; the Chloritic Marl, near Chardstock, and in the Red Chalk, in the highest of the tinted bands at Speeton Cliff, Yorkshire, at the part where the pink and white sems alternate (Rev. T. Wiltshire).

Foreign Distribution.—In France, in the 'Étage Cénomanien,' according to M. Cotteau, Rouen (Seine-Inférieure); Pourrain, Saint-Sauveur (Yonne); La Fauge près le Villard-de-Lans (Isère); Saint-Aignan en Vercors (Drôme); Castellanne (Basses-Alpes). In Germany, in the Lower Pläner (stage with *Ammonites Rhotomagensis*) = Chalk-marl of English authors; at Langelsheim near Brunswick (Strombeck); at Rethen, near Hildesheim (Römer), near Paderborn (Goldfuss), from the Gault of the Mountain of Fis, according to Desor, and from the Étage Albien, Cheville, Alpes Vaudoises = Lower Chalk (Renevier).

Discoidea minima, *Agassiz*, 1840. Pl. XLVII, fig. 4 *a*—*h*.

Discoidea minima,	*Agassiz.*	Catal. Syst. Ectyp. Foss., p. 7, 1840.
—	—	*Desor.* Monogr. des Galérites, p. 56, pl. viii, figs. 1—4, 1842.
—	—	*Morris.* Catalogue of British Fossils, p. 52, 1843.
—	—	*Agassiz* and *Desor.* Catal. raisonné des Échinides, 1847.
—	—	*Morris.* Catalogue of British Fossils, p. 77, 2nd ed., 1854.
—	—	*McCoy.* Contributions to British Palæontology, p. 67, 1854.
—	—	*Cotteau.* Paléontol. Française, t. vii, pl. 1012, figs. 1—7, 1866.

Diagnosis.—Test small, sub-circular; height and length equal; upper surface inflated; base slightly convex; border round; ambulacra half the width of the inter-ambulacra; tubercles form regular series on the sides of the areas; mouth and vent moderately wide.

Description.—The specimens of this Urchin sent to me for drawing and description were so imperfect that I requested Mr. Bone to make accurate copies of the very capital figures of this species given by my friend M. Cotteau in the 'Paléontologie Française,' pl. 1012, figs. 1—7.

The test is small and sub-circular; the upper surface inflated and convex; the base slightly swollen in the middle, and round at the border.

The ambulacra half the width of the inter-ambulacra, with two rows of primary tubercles extending from the disc to the peristome (fig. 4 *g*, *h*); the plates supporting, besides, numerous fine granules, which are disposed around the base of the tubercles. The poriferous zones are narrow, the pores round, unigeminal, slightly oblique, and well spaced out from each other (fig. 4 *f* and fig. 4 *g*).

The inter-ambulacra are formed of large plates; at the ambitus each plate carries three tubercles, two of which are more conspicuous and persistent than the others, and reach higher up the sides. The central tubercles extend from the disc to the peristome, and the zonal series is absent above and below; the larger tubercles grow on two slightly elevated longitudinal carinal lines (fig. 4 *f*), indicated by the direction of the shading in the figures. The granulations on the plates are very fine and form horizontal beaded chains of great delicacy; the primary tubercles at their base have circular depressed areolas without encircling granulations.

The small mouth-opening has a circular or sub-decagonal peristome and opens in the centre of the base, which is slightly convex (fig. 4 *a*).

The vent is oval, and acuminated at the inner extremity; it occupies nearly two thirds of the space between the peristome and posterior border; the aperture was closed by a series of ten anal plates, unequal in size (fig. 4 *h*) and covered with small granules; the periprocte at the inner border is surrounded by seven small plates let into a space around the vent like a piece of mosaic.

The apical disc is small and composed of five perforated ovarial plates, the right antero-lateral being much the largest and covered with the madreporiform body; the surface of the other four is crowded with granules; and the small cordate oculars are wedged into the angles formed by the ovarial plates.

Affinities and Differences.—The general form and arrangement of the tubercles on *D. minima* resemble the young condition of *D. subuculus*, of which some authors consider it a small variety. M. Cotteau[1] has had an opportunity of examining with care a great number of specimens collected from different localities, and says that he has acquired the certainty that this species differs essentially from *D. subuculus*, not only in its size, which is constantly smaller, but in its greater height, more inflated sides, and convex base, and by its granules, which are more closely set together and disposed in more regular lines on the plates, and always by its apical disc, which is composed of five perforated ovarial plates.

[1] 'Paléontologie Française,' tome vii, p. 35.

Locality and Stratigraphical Position.—This species is extremely rare; on the authority of Professor M'Coy one only has been found in England in the Upper Greensand of Cambridge; and this type-specimen, with its anal plates, is in the Woodwardian Museum of Cambridge.

The Foreign Localities, according to M. Cotteau, are Rouen (Seine-Inférieure), Neuchâtel près Boulogne (Pas-de-Calais); Verronnet (Eure); La Chapelle Saint-Aubin, Les Menus près la Loupe (Sarthe); environs de Villedieu (Loir-et-Cher), from the Étage Turonien, where it is very rare.

DISCOIDEA FAVRINA, *Desor*, 1842, Pl. XLVIII, fig. 1 *a*—*g*.

DISCOIDEA FAVRINA, *Desor*. Monogr. des Galerites, p. 62, pl. vii, figs. 12—16, 1842.
— — *Forbes*. Mem. of Geol. Survey, Decade I, descrip. pl. viii, 1849.

Diagnosis.—Test sub-pentagonal; upper surface elevated, round, more or less inflated; base flat; mouth-opening small; vent oblong, midway between the peristome and border; inter-ambulacra wide, two prominent rows of primary tubercles; ambulacra narrow; five plates opposite one inter-ambulacral.

Dimensions.—Height seven tenths of an inch; latitude one inch.

Description.—This Urchin was first figured by my friend Professor Desor under the name *Discoidea rotula;* he informs us that when the plates were executed for his beautiful memoir on the *Galeritidæ* his knowledge of the *D. rotula* was limited to moulds of this species, or to moulds with a fragment of the test adherent, but so much effaced that it was impossible to study its intimate structure. As he had recognised among the Urchins sent to M. Agassiz by M. Alex. Brongniart from the "Glauconie" of Rouen, who had first figured *D. rotula*, a species very similar in form to the others, he thought he could identify it with *D. rotula;* subsequently M. Favre, of Geneva, sent from Saxonnet a specimen of *D. rotula* with its test perfectly preserved. This specimen he compared with those sent from Rouen, when he found that the tubercles on *D. rotula* from Saxonnet were very different from those on the specimens from Rouen, for instead of being scattered without apparent order on the surface of the test, they formed horizontal series very continuous, resembling those on *D. macropyga*. This discovery determined M. Desor to separate the Saxonnet specimen from those derived from the "Glauconie" of Rouen, and to describe it under the name *Discoidea Favrina*.

The specimen I have figured from the British Museum collection was identified by the late Dr. Woodward as the representative of Desor's species from the Upper Greensand; the test has a subpentagonal outline, is considerably elevated with a convex dorsal surface

(fig. 1 *c*); the base is flat; the mouth-opening small (fig. 1 *b*, and the oblong vent occupies a space midway between the peristome and the border.

The ambulacral areas are formed of small irregular-shaped plates, many of a triangular form. On each of these is a primary tubercle, so placed that on every three plates we observe an oblique disposition like this ⋮ The poriferous zones are very narrow, and there is one pair of pores opposite each of the ambulacral plates, of which five are packed within the vertical depth of one inter-ambulacral. Fig. 1 *e* shows the structure of one of these areas magnified four diameters, and the form of the individual plates is well delineated in this drawing.

The inter-ambulacral areas are four times the width of the ambulacral; the tubercles are arranged with much regularity, and two series in each area, situated about one third the distance between the zones and the median sutures, are formed of larger primary tubercles, which are elevated on a slight carinal ridge of the plate, and extend uninterruptedly from the apical disc to the peristome; this ridge is faintly represented by a vertical line in fig. 1 *e*; besides the longitudinal series there are several other tubercles very regularly arranged, and between them the surface of the plates is covered with a microscopic granulation. The tubercles are larger at the base, and form horizontal rows on the plates (fig. 1 *g*), where several of the basal plates are drawn four diameters to show this arrangement of the tubercles with their encircling granules. The structure of the basal portion of the single inter-ambulacrum with the oblong vent is well shown in fig. 1 *f*, where the two primary series of tubercles flank the periprocte, and others fill up the intermediate spaces; in this figure, likewise magnified four diameters, we observe that each alternate plate of the basal portion of the ambulacra supports a primary tubercle.

The apical disc (fig. 1 *d*) is formed of five irregular, pear-shaped ovarial plates, four of which are perforated; the right antero-lateral is larger than the others, and supports as usual the madreporiform body. The five heart-shaped oculars with their microscopic orbits are wedged between the ovarials; the elements of the disc are well soldered together and form a compact body.

The mouth-opening is small, and occupies a slight central depression (fig. 1 *b*).

Affinities and Differences.—This Urchin closely resembles *D. cylindrica*, a species which presents many interesting varieties of size and form from different localities, scarcely two specimens from the Grey Chalk of Folkestone, or the Lower Chalk of the South of England, being precisely alike. The same remark may be made of the specimens of *D. cylindrica* now before me from the Pläner of Hanover, the Craie Chloritée of La Fauge (Isère), and the Étage Cénomanien of Saint-Aignan (Drôme), and of other departments of France; such being the case I accept *D. Favrina* only as a provisional species until a series of specimens have been found which may determine more accurately its specific characters.

Locality and Stratigraphical Position.—The specimen I have figured belongs to the

British Museum, and was obtained from the Upper Greensand. Professor Desor's type was collected by Professor Favre from the same stage at Saxonnet. My late colleague, Professor Forbes, stated in his note on allied British species of *D. cylindrica:* "I think it not improbable that in the end we shall have to adopt the specific appellation *Favrina* for the Greensand species; and that the Chalk specimens alluded to will prove varieties of *cylindrica;* but a comparison of the types themselves only can settle the matter." 'Memoirs of the Geological Survey, British Organic Remains,' Decade i; note to plate viii, *Discoidea cylindrica.*

Discoidea Dixoni, *Forbes*, 1850. Pl. XLVIII, fig. 2 *a—d*, fig. 3 *a*, *b*.

Discoidea Dixoni, *Forbes*, in Dixon's Geology of Sussex, pl. xxiv, figs. 13, 14, 1850.
— — *Forbes*, in Morris's Catal. of British Fossils, 2nd ed., p. 77, 1854.

Diagnosis.—Test small, circular; upper surface elevated, dorsum convex, sides inflated; base slightly convex; mouth-opening and vent very small; inter-ambulacra wide; two rows of primary tubercles more prominent than the others; surface of the plates finely granulated; basal tubercles larger; apical disc small; the five genital plates all perforated.

Dimensions.—Height five twentieths of an inch; latitude three tenths of an inch.

Description.—In describing this Urchin, which he found in Mr. Frederick Dixon's 'Cretaceous Fossils from Sussex,' my late colleague, Professor Edward Forbes, observes: "In form and size this species resembles *Discoidea subuculus;* also in the proportional number of ambulacral as compared with the inter-ambulacral plates, and the granulation of their surfaces. It is distinguished, however, by the proportions and dimensions of mouth and anus as compared with the whole ventral surface. The mouth, instead of being (as in *subuculus*) nearly equal in diameter to the distances between its sides and the margin of the inferior surface, is scarcely half that size, and the anus, instead of occupying the greater part of the space between the mouth and the margin, fills less than half of it."[1]

This elegant little Urchin has likewise the upper surface elevated, the sides inflated, and the base slightly convex, a careful comparison of type-specimens discloses the affinities and differences subsisting between these congeneric forms.

The ambulacral areas, half the width of the inter-ambulacral, have a row of small tubercles on the zonal side of the plates, one tubercle on every other plate in the column, and a second row more irregular than the former, filling in only the wider part of the area

[1] 'Dixon's Geology and Fossils of Sussex,' p. 341.

(fig. 2 *d*); the surface of the plates is likewise covered with numerous microscopic granules set in horizontal rows. There are four ambulacral plates opposite each inter-ambulacral, and a pair of oblique pores correspond to each ambulacral plate.

The inter-ambulacral areas have two rows of primary tubercles, nearer the zonal than the sutural side of the plates; these rows extend from the disc to the peristome (fig. 2 *a*, *b*, and fig. 3 *a*); each plate besides, near the ambitus, supports four smaller tubercles placed less regular on the surface than those forming the vertical series. The surface of the plates is likewise covered with a most abundant development of microscopic granules arranged in horizontal rows in the direction of the long diameter of the plate. Fig. 2 *d* shows this condition of the surface in the plates of both areas magnified six times; all the tubercles are perforated and crenulated. Those on the base are large as shown in fig. 3 *a*, where the test is magnified twice; and the details of a portion of the same are very well exhibited in fig. 3 *b*, where a portion of both areas is accurately drawn eight times the natural size. These admirable drawings by my friend Mr. C. R. Bone render any detailed description unnecessary, as they are correct representations of the minute anatomy of the test carefully drawn under a lens.

The apical disc is level with the general surface, and all the five ovarial plates are perforated (fig. 2 *c*), as in *D. minima*.

The base is slightly convex; the small mouth-opening is quite superficial, and its peristome is marked with microscopic incisions; the vent is oblong, and occupies the middle of the space between the peristome and border, which is rounded and inflated, but never angular as in *D. subuculus*.

Affinities and Differences.—When compared with *D. subuculus* it is distinguished by the proportions and dimensions of mouth and vent as compared with the whole ventral area, which are much larger in *D. subuculus* than in *D. Dixoni*. M. Cotteau is inclined to unite *D. Dixoni* to *D. minima*, as the apical disc in both has each of the five genital plates perforated, whereas, in other congeneric forms, only four of the ovarials are so.

Locality and Stratigraphical Position.—The type-specimen was collected from the White Chalk of Sussex, and the original of our figures belongs to the British Museum.

Genus—Echinoconus, *Breynius*, 1732.

Conulus, *Klein*, 1734. Echinites, *Leske*, 1778. Galerites, *Lamarck*, 1801.

Shell round, oval, or pentagonal; enlarged a little before and slightly contracted behind; upper surface more or less elevated, and having a rounded or conoidal form; summit central; under surface flat, border rounded or angular, sometimes concave in the middle, rarely undulated by the depression of the ambulacra.

Mouth-opening small, circular, decagonal, in the centre of the base; peristome

notched with internal auricles, and supporting a pentagonal masticating apparatus; vent oval, acuminated above, opening on the border, either marginal or infra-marginal.

Ambulacra lanceolate; poriferous zones narrow; pores unigeminal, except near the peristome, where they are trigeminal.

Inter-ambulacra wide, with numerous primary tubercles, small on the sides and upper surface, and larger at the base; in both crenulated and perforated; miliary granules either microscopic and homogeneous, filling up all the intermediate spaces, or larger and more developed, and disposed in regular circles around the primary tubercles.

The apical disc, placed at the centre of the summit, is quadrangular, solid, and compact, and composed of four perforate and one imperforate ovarial plates; the right antero-lateral is much the largest, and is prolonged posteriorly with a portion of the madreporiform body into the centre of the disc; the three other plates are much smaller, and terminate externally in prominent angles, in which the genital aperture is pierced. The five ocular plates are very small, and interposed between the angles of the ovarials.

The genus *Echinoconus* is distinguished from *Discoidea* by the position of the vent, and the absence of projecting processes from the interior of the test; from *Pygaster* by its infra-marginal vent, absence of a dorsal aperture, and its elevated conoidal test; from *Holectypus* by its elevated profile and much smaller mouth- and vent-openings; from *Pyrina* in the quadrangular structure of the apical disc, its more pentagonal and conoidal form and regular decagonal peristome provided with five jaws, and by its infra-marginal vent.

In Professor Desor's valuable Monograph on the Galerites twelve species are beautifully and accurately figured belonging to the genus *Echinoconus*, such as I have defined it; after a careful study of this series, and a comparison with a collection of specimens of many varieties now before me, I have come to the conclusion that they all are referable to four types, each of which may be described as a distinct species. These are—

1st. *E. castanea*.—Has an oblong form, enlarged anteriorly and contracted posteriorly; the upper surface depressed; it belongs to the Upper Greensand, the Chalk-marl, and Lower Chalk.

2nd. *E. sub-rotundus*.—Has a tall, round, or sub-globular test, and appears to be one of the many forms which were figured by Klein and described by Leske under the name *Echinites vulgaris;* the specimens grouped together were siliceous moulds, entirely destitute of shell, and clearly referable to several specific forms; one of them may represent the beautiful test I have figured; but as it is impossible to determine its identity, I prefer retaining the appropriate name given to it by Mantell. This species is collected from the Lower Chalk of Sussex, and several of my specimens came from Lewes.

3rd. *E. conicus*.—This is the true ECHINOCONUS VERE CONICUS; *marino-terrestris, creta repletus; ex cretæ fodinis Cantianis*, of Breynius; two years later Klein named it *Conulus albogalerus* on account of its fancied resemblance to the white caps worn by the priests of Jupiter; it has been frequently figured (see the synonyms of this species) and

described under that name; there never was any mistake about the typical form of this species; although its generic and specific names have been frequently changed; in justice to its original author I have restored its old name. It appertains to the Medial Chalk.

4th. *E. abbreviatus*.—This species was proposed by Lamarck for a large flint mould figured by Leske; but whether that form is the prototype of the Urchin to which I now apply the name is uncertain, for moulds seldom possess specific characters and ought never to have been described and figured as representatives of species; moulds having been so admitted by former authors have led to interminable confusion, and *E. abbreviatus* is one of many examples that might be adduced of this error. My learned friend, Professor Desor, in his valuable Monograph, has cited thirty-one references to *Galerites abbreviata*, Lamk., and given excellent figures of one of the varieties, which is the *G. vulgaris* of Goldfuss and Bronn. The first figure that can be relied upon as truly representing *E. abbreviatus*, Desor, is that given in Woodward's 'Geology of Norfolk,' pl. v, figs. 2 and 3, p. 47, where it is entered in his stratigraphical list of fossils as *G. vulgaris*, I have a series of type-specimens of this Urchin from the same chalk pits, and have ascertained the accuracy of this identification; we next find that *G. vulgaris*, Woodward, is *G. angulosa*, Desor, pl. iv, figs. 5—7, and *Caratomus hemisphæricus*, Desor, pl. v, figs. 14—19; both these species were drawn and described from English specimens collected from the White Chalk of Norwich, and sent by the Marquis of Northampton to Professor Agassiz, so that there can be no mistake about the identity of the original specimens most beautifully and accurately figured in Desor's valuable work.

A.—*Species from the Lower Chalk.*

ECHINOCONUS CASTANEA, *Brongniart*, 1822. Pl. LI, fig. 2 *a—g*, fig. 3.

NUCLEOLITES CASTANEA,	*Brongniart.* Géol. Environs Paris, pl. o, figs. 13, 14, 1822.
— —	*Defrance.* Dict. Sc. Nat., tome 35, p. 214, 1825.
GALERITES CASTANEA,	*Agassiz.* Échinod. Foss. Suisse, pl. xii, fig. 7—9, p. 77, 1839.
CATOPYGUS CASTANEA,	*Agassiz.* Prodrome des Échinides, p. 185, 1835.
PYRINA CASTANEA,	*Desmoulins.* Études Échinides, p. 185, 1837.
GALERITES ROTHOMAGENSIS,	*Agassiz.* Cat. Syst. Ectyp., p. 7.
— CASTANEA,	*Desor.* Monogr. des Galerites, pl. iv, figs. 12—16, p. 23, 1842.
— —	*Agassiz* and *Desor.* Catal. rais. des Échinides, Ann. Sc. Nat., 3rd series, vol. vii, p. 149, 1847.
— —	*Morris.* Catalogue of British Fossils, p. 80, 1854.
— —	*Forbes.* Mem. Geol. Surv., Decade iii, pl. vii, 1850.
ECHINOCONUS CASTANEA,	*d'Orbigny.* Revue de Zool., p. 21, 1854.
GALERITES ROTHOMAGENSIS,	*Sismonda.* Échin. Foss. de Nizza p. 51, pl. 2, figs. 8—10, 1843.
ECHINOCONUS CASTANEA,	*Cotteau.* Paléontol. Française, t. vi, p. 503, pl. 990.
— —	*De Loriol.* Ours. de la Suisse, pl. xiv, fig. 1, 1873.

Diagnosis.—Test oval, pentagonal, enlarged anteriorly, contracted and rounded posteriorly; upper surface elevated and convex; sides inflated; base contracted, slightly convex or flat. Mouth-opening small, roundish, and central; vent large, elliptical, marginal; ambulacra narrow, prominent, corresponding to the angles of the test. Poriferous zones linear, pores unigeminal; apical disc small, central, soldered to the plates of the test.

Dimensions.—The following measurement of six specimens is given to show the variability of the proportions of this species.

	A.	B.	C.	D.	E.	F.
	G. C.	G. C.	G. C.	U. G.	C. M.	C. M.
Length .	2	$1\frac{6}{10}$	$1\frac{1}{10}$	$1\frac{1}{10}$	1	$\frac{9}{10}$
Breadth .	$1\frac{8}{10}$	$1\frac{4}{10}$	$1\frac{1}{10}$	1	$\frac{9}{10}$	$\frac{9}{10}$
Height .	$1\frac{2}{10}$	$1\frac{3}{20}$	$\frac{17}{20}$	$\frac{9}{10}$	$\frac{7}{10}$	$\frac{6}{10}$

G. C. means Gritty Chalk; U. G. Upper Greensand; C. M. Chloritic Marl; and the measurements are in inches and parts of an inch.

Description.—The two Urchins, from the cretaceous rocks of Savoy, drawn in pl. Q, figs. 14 and 17, of M. Alex. Brongniart's 'Description Géologique des Environs de Paris,' and described under the names *Nucleolites castanea*, Al. Br., fig. 14, and *Nucleolites depressa*, Al. Br., fig. 17, have occasioned much diversity of opinion among Palæontologists in consequence of the unsatisfactory condition of the specimens themselves and the inadequacy of the figures for subsequent determination.

Having collected many specimens of this species showing its various stages of growth, I am enabled to state that the two forms figured by Brongniart are only different conditions of the same species, my larger shells agreeing with *N. castanea* and the smaller with *N. depressa*.

I have given the anatomy of the test with ample details of structure of the largest specimen I have seen from a very fine fossil in my collection (fig. 2 *a*—*g*); the smaller and commoner shell is drawn in fig. 3.

The distinctness of the two forms has been persistently maintained by most foreign authors, as our table of synonyms shows; nevertheless in this, as in other matters, authority must bend to facts, and dry anatomy settle the question of the unity of the species.

The British specimens of *Echinoconus castanea* nearly all belong to the small variety; these were collected from the Chloritic Marl near Chaldon, Dorset, and most of them have the test beautifully preserved. My larger specimens were obtained from the bed of hard gritty siliceous Chalk near Folkestone, and are equally well preserved, so that both varieties belong to the lower portion of the Cretaceous formation.

All my specimens are of an ovate or sub-globular form, inclining to a pentangular or

hexangular outline. They vary much in the degree of height and tumidity, as compared with their length and breadth; the upper surface is sometimes convex and sometimes depressed; the anterior half of the shell is more enlarged than the posterior, the widest portion being the region across the antero-lateral ambulacra (fig. 2 *b*, *d*). The obscure angles, when they are five, correspond to the ambulacral areas; when there is a sixth it is in the centre of the single inter-ambulacrum. The sides are so rounded that their most tumid portions are central or sub-central.

In the large specimen (fig. 2 *b*) the base is flat, inclining to concave, in the smaller specimens from the Chloritic Marl, as in fig. 3, the border is so rounded off at the sides that it becomes slightly convex, in the still smaller varieties it is mostly flat.

The ambulacral areas are narrow, tapering towards the disc and peristome, and widest above the ambitus (fig. 2 *a*, *b*, *c*); they are formed of narrow plates four or five of which are opposite one inter-ambulacral; four rows of tubercles set in a zig-zag arrangement occupy the area (fig. 2 *c*), and those at the base are much larger than those on the sides. The poriferous zones are linear and the very small pores are set in triple oblique pairs, six or eight pair being opposite the vertical height of one inter-ambulacral plate.

The inter-ambulacral areas, four times the width of the ambulacral, are formed of broad and well-developed plates (fig. 2 *a*, *b*, *c*); in the large specimen (fig. 2 *c*), twelve of these are found in each column between the disc and border, and six between the border and peristome; each plate supports two rows of tubercles set in irregular horizontal lines above each other, four or five tubercles occupying each row. Fig. 2 *e* shows two complete and two incomplete inter-ambulacral plates, and a portion of the ambulacral area and poriferous zones magnified four times; besides the primary tubercles the surface of the plates of both areas is covered with numerous microscopic granules. The basal have larger tubercles than the lateral plates. Fig. 2 *f* shows two of these plates from the middle of the base magnified four times; the crenulations of the boss and the perforations at the summit are better seen in this than in the other figure.

The apical disc is composed of five genital and five ocular plates; four of the former are perforated and the single plate is imperforate (fig. 2 *g*). The right antero-lateral genital plate is much the largest and supports the madreporiform body, which extends backwards and fills the central portion of the disc. The small cordate perforated oculars are wedged into the angles formed by the ovarials and complete the circle of the disc, the elements of which are well soldered together to form a compact structure; and the surface of the plates uncovered by the spongy body is studded with close-set microscopic granules.

The mouth-opening is small and oval (fig. 2 *b*), the long diameter extending obliquely across the base from the left to the right side; the peristome is obscurely decagonal and divided into ten nearly equal-sized lobes. The base is sometimes flat, or slightly concave, as in the large specimen (fig. 2 *b*), or it is flattened in the centre and rounded off at the sides, or sometimes it is slightly convex (fig. 3); in either case the mouth-opening is nearly in the middle.

The vent is elliptical (fig. 2 *d*); one third larger than the mouth in vertical dimensions; it is placed at the lower part of the posterior border in the single ambulacrum immediately below the margin (fig. 2 *b*), or just within the range of the same; it varies a little in the degree of its elevation in the different specimens I have compared.

Affinities and Differences.—This species is distinguished from its congeners by its elongated and pentagonal form; it is enlarged anteriorly and tapers slightly posteriorly, its greatest transverse diameter being across the antero-lateral ambulacra; it becomes a little narrower towards the posterior border, which is rounded with an elongated ridge rising from the upper angle of the elliptical vent. The primary tubercles of both areas are of the same size; they are sunk in areal depressions and scarcely rise above the general surface of the plates, the whole of the intermediate structure being covered with numerous close-set granules; so that the shell of *Echinoconus castanea* feels smooth to the touch when compared with that of *Echinoconus conicus* or *E. abbreviatus*. In this respect it resembles *E. subrotundus;* the latter, however, has a smoother test, with fewer and smaller tubercles on the plates; besides this character the elongated pentagonal form is very characteristic of *E. castanea*.

Locality and Stratigraphical Position.—*Echinoconus castanea* is collected very rarely in the Upper Greensand. A few specimens have been found in this formation at Chute Farm, near Warminster, and one of these now lies before me. Small forms of this Urchin in fine preservation are very characteristic of the Chloritic Marl near Chard, a bed of Chalk Marl tinged green with scattered particles of silicate of iron, which lies between the Chalk Marl and Upper Greensand, and contains a most interesting suite of *Echinidæ*, all of which likewise occur in the Upper Greensand formation. The large figured specimen was obtained from the Chalk Marl near Lewes, in Sussex. I have others that were collected from the bed of hard gritty Lower Chalk near Folkestone, a stratum which has yielded many interesting Urchins, as *Salenia granulosa, Cyphosoma simplex*, and numerous Polyzoa. It belongs, therefore, to the lower division of the Cretaceous formation.

Foreign Distribution.—It was collected by Mr. Alex. Brongniart in the Albien stage of the Chalk at the Mountain of Fis, in Savoy; in the same stage near Nice, by M. Cailliaud; in France at Escragnolles (Var), by MM. Cotteau and Kœchlin; near Près, Valley de Rencurel, near Grenoble (Isère), by M. Albin Gras.

ECHINOCONUS SUBROTUNDUS, *Mantell*, 1822. Pl. LII, fig. 1 *a—f*; Pl. LIII, fig. 2 *a—f*, fig. 3.

CONULUS SUBROTUNDUS,		*Mantell.* Geol. of Sussex, p. 191, tab. xvii, figs. 15—18, 1822.
GALERITES SUBROTUNDA,		*Agassiz.* Monogr. des Radiaires, Mem. Soc. des Sc. Nat. de Neuchatel, t. i, p. 186, 1836.
—	—	*Desmoulins.* Études sur les Échinides, p. 256, 1837.
—	—	*Dujardin.* In Lamarck's Animaux sans Vertébres, 2e ed., t. iii, p. 313, 1840.
—	—	*Desor.* Monogr. des Galérites, p. 18, tab. ii, figs. 11—14, 1842.
—	—	*Morris.* Catalogue of British Fossils, p. 53, 1843.
—	—	*Agassiz* and *Desor.* Catal. rais. des Échinides, Ann. Sc. Nat., 3e série, t. vii, p. 148, 1847.
—	LESKEI,	*Desor.* Id., p. 148, 1847.
—	SUBTRUNCATA,	*d'Orbigny.* Prod. de Pal., t. ii, p. 272, 1850.
—	SUBROTUNDUS,	*Forbes.* In Dixon's Geol. of Sussex, p. 340, 1850.
—	—	*Forbes.* Mem. of Geol. Survey, decade iii, p. 6, 1850.
—	—	*Morris.* Catal. of Brit. Foss., 2nd ed., p. 80, 1854.
ECHINOCONUS	—	*d'Orbigny.* Rev. et Mag. Zoologie, t. vi, p. 20, 1854.
—	—	*Cotteau.* Paléontol. Française terrains Crétacés, t. vi, p. 517, pl. 997, figs. 8—12, 1856.
GALERITES	—	*Desor.* Synopsis des Échinides Foss., p. 183, 1856.
ECHINOCONUS	—	*Cotteau.* Échinides de la Sarthe, p. 283, pl. xlvii, fig. 4, 1860.

Diagnosis.—Test subcircular, rounded anteriorly, a little contracted, and subangular posteriorly; upper surface elevated, sub-conoidal and convex; base flat, rounded at the border, sides a little inflated; mouth-opening small, roundish central; vent large, marginal, elliptical; ambulacra narrow, plates of both areas covered with small flat, equal-sized tubercles.

Description.—Under the name *Galerites vulgaris*, Leske, it is probable that moulds of *E. subrotundus* have been included. Klein's tab. xiii, fig. C—K, and tab. xiv, fig. A—K, are cited by Lamarck as types of *G. vulgaris*. As these figures all represent siliceous moulds, a doubt may be allowed to rest on their identity with the form I have figured in Plates LII and LIII. Dr. Mantell also gave the name *Conulus subrotundus* to a doubtful cast; but Desor has published excellent figures of this species from an English specimen collected in the Isle of Wight, and contained in the Museum at Neufchatel. Professor

Agassiz made a cast of this specimen for his collection of moulds of fossil Echinoderms. This form, therefore, has become classical, and I prefer to retain it, with Mantell's name, as M. Cotteau has done, in his beautiful work on the 'Fossil Échinides of the Department of the Sarthe.'

Echinoconus subrotundus is a common Urchin in the Lower English Chalk. The subcircular outline being rounded anteriorly, and a little contracted posteriorly, sometimes is slightly sub-pentagonal, as in the large specimen figured in Pl. LIII, fig. 2 *a*, *b*; the upper surface is elevated and convex, or sub-conoidal. A fine series of well-preserved specimens gives about equal numbers of both forms. The base is narrow and flat, and much rounded off at the border; the sides are tall and convex, not much inflated. Mr. Bone has given admirable figures of this species in Pls. LII and LIII, with full details of the anatomy of the test.

The ambulacral areas are narrow and lanceolate, Pl. LII, fig. 1 *b*, *c*, Pl. LIII, fig. 2 *a*, *b*, and composed of small plates, of which five are opposite one large inter-ambulacral plate. Pl. LIII, fig. 2 *e*, representing a portion of the large test near the ambitus magnified four times, shows the structure of the ambulacra; two rows of tubercles occupy the area, and form thereon irregular oblique rows; the poriferous zones are extremely distinct; the pores are very small, one oblique pair corresponding to each plate.

The inter-ambulacral areas are nearly three times the width of the ambulacral, and formed of wide deep plates (Pl. LII, fig. *d*, Pl. LIII, fig. 2 *e*). In the large specimen (Pl. LIII, fig. 2 *c*, *d*) there are fifteen plates in each column between the border and the disc, and six or seven between the border and the periostome; each plate supports three or four longitudinal series of tubercles arranged in quincuncial order, fig. 2 *e*, each surrounded by an areola, and having its summit perforated; the tubercles on both areas are very small, indistinct, and nearly homogeneous, and can only be seen with a lens, so that the shell appears quite smooth to the naked eye. The inter-tubercular surface is covered with microscopic granulets.

The base is flat, Pl. LII, fig. 1 *a*, Pl. LIII, fig. 2 *b*, sometimes it is undulated from the convexity of the basal inter-ambulacra, and the tubercles are a little larger than those on the sides; Pl. LIII, fig. 3, represents the arrangement they assume on three basal plates magnified six times; the bosses are crenulated, and the tubercles perforated.

The mouth-opening is small and central, about one séventh the diameter of the base; and the periostome presents very feeble indications of entailles (fig. 2 *b*).

The vent is larger than the oral opening, and occupies the border (Pls. LII and LIII); it has an elliptical form, placed vertically, the most acute angle being directed upwards (Pl. LIII, fig. 2, *b*, *d*); the opening is on the same plane with the border of the test, and the single inter-ambulacrum is neither tumid or rostrated, like *E. abbreviatus* (Pl. LIII, fig. 1).

The apical disc is firmly soldered to the surrounding plates, and is almost always well preserved; it is small, and consists of five ovarial plates, four of which are perforated, and one single imperforate, the antero-lateral plate is large, and projects into the centre of

the disc, supporting on its surface the madreporiform body. The five ocular plates are very small cordate bodies, wedged between the ovarials (Pl. LII, fig. *e*, Pl. LIII, 2*f*). The surface of all the discal elements is covered with microscopic granulets.

Affinities and Differences.—This species resembles some globular varieties of *E. vulgaris*, and is often grouped with these in collections. It has a more globular form and is less elongated, the ambitus is more rounded, and the vent opens higher up in the border. It differs from *E. castanea* in the general outline of the test by being more globular, and elevated with a more convex dorsal surface. The same characters distinguish this species from *E. conicus*, from which, however, it further differs in having smaller tubercles, and a more microscope form of granulation. It differs from *E. abbreviatus* in the general form of the test, and in having much smoother plates, from the smallness of its tubercles; those in *E. abbreviatus* being larger, and surrounded by a more prominent granulation; the vent likewise is more inferior, and the single interambulacrum neither tumid nor rostrated as in this species.

Locality and Stratigraphical Position.—I collected my large specimen from the Lower Chalk, near Lewes, in Sussex; it is found in the same stratum at Charing, in Kent, and in the Lower or Hard Chalk at Feltwell Marborough, in Norfolk, it is therefore a fossil characteristic of the Lower Chalk, and in this respect differs from *E. conicus*, *E. globulus*, and *E. abbreviatus*, which all appertain to the Medial and Upper Chalk. The Rev. T. Wiltshire, F.G.S., has collected this species in the Lower Chalk, near Folkestone, from a stratum fifteen feet above the bed of hard gritty chalk, but never in the gritty chalk itself.

B.—*Species from the Medial Chalk.*

ECHINOCONUS CONICUS, *Breynius*, 1732. Pl. XLIX, figs. 2, 3, 4; Pl. L, figs. 1—6.

ECHINOCONUS VERÈ CONICUS,	*Breynius.*	Sched. de Echinis, p. 57, pl. iii, fig. 12, 1732.
CONULUS ALBOGALERUS,	*Klein.*	Natur. dispositio Echinoderm., p. 24, tab. xiii, A, B, 1734.
ECHINITE CONOIDE,	*Bourguet.*	Trait. des Petrif., p. 77, pl. liii, fig. 360, 1742.
CONULUS ALBOGALERUS,	*Leske.*	Apud Klein, p. 162, tab. xiii, A, B, 1778.
ECHINUS —	*Gmelin.*	Systema Naturæ, p. 3181, No. 46, 1789.
— —	*Bruguière.*	Tab. Encycl. Atlas, pl. clii, figs. 5, 6, 1791.
CONULUS —	*Parkinson.*	Organic Remains, vol. iii, pl. ii, figs. 10, 11, 1811.
GALERITES —	*Lamarck.*	Animaux sans Vert., t. iii, p. 20, 1816.
— —	*Defrance.*	Dic. Sci. Nat., t. xviii, p. 86, 1820.
— —	*Brongniart.*	Foss. envir. de Paris, p. 631, pl. 1, fig. 12, 1822.

GALERITES PYRAMIDALIS,	*Brongniart.* Idem.
CONULUS ALBOGALERUS,	*Mantell.* Geol. of Sussex, p. 190, pl. xvii, figs. 16—19, 1822.
GALERITES —	*Deslongchamps.* Zoophytes Ecycl. Method., t. ii, p. 431, 1824.
— —	*Goldfuss.* Petrefacta, t. i, p. 127, pl. xl, fig. 19, 1826.
CONULUS —	*Fleming.* History of British Animals, p. 481, 1828.
GALERITES —	*Stokes.* Trans. Geol. Soc. Lond., 2nd ser., vol. ii, p. 406, pl. xlv, figs. 14, 15, 1829.
ECHINONEUS —	*De Blainville.* Zoophytes Dic. Sc. Nat., t. lx, p. 194, 1830.
DISCOIDEA ALBOGALERA,	*Agassiz.* Monogr. des Radiair., Mém. Soc. Neuf., t. i, p. 186, 1836.
— —	*Desmoulins.* Études sur les Échinid., p. 248, 1837.
GALERITES PYRAMIDALIS,	*Desmoulins.* Idem.
— ALBOGALERUS,	*Agassiz.* Catal. Syst. Ectyp. Foss., p. 6, 1839.
— PYRAMIDALIS,	*Agassiz.* Idem.
— ALBOGALERUS,	*Dujardin.* In Lamarck, 2nd ed., t. iii, p. 306, 1840.
— PYRAMIDALIS,	*Dujardin.* In Lamarck, idem.
— ALBOGALERUS,	*Rœmer.* Norddeutschen Kreidegebirges, p. 32, 1840.
— —	*Desor.* Monogr. des Galérites, tabs. i and xiii, p. 11, 1842.
— PYRAMIDALIS,	*Desor.* Idem, p. 13, tab. i, figs. 1—3.
— ANGULOSA,	*Desor.* Idem, p. 22, tab. iv, figs. 5—7.
— ALBOGALERUS,	*Morris.* Catalogue of British Fossils, p. 53, 1843.
— —	*Agassiz* and *Desor.* Catal. rais. des Échinides, Ann. Sc. Nat., 3rd ser., t. vii, p. 148, 1847.
— PYRAMIDALIS,	*Agassiz* and *Desor.* Idem.
— ANGULOSA,	*Agassiz* and *Desor.* Idem.
— —	*d'Orbigny.* Pal. Stratigraph., t. ii, p. 272, 1850.
— ALBOGALERUS,	*d'Orbigny.* Idem.
— —	*Forbes.* In Dixon's Geol. of Sussex, p. 340, 1850.
— —	*Sorignet.* Oursin Foss. de l'Eure, p. 40, 1850.
— —	*Forbes.* Mem. Geol. Survey, decade iii, pl. viii, 1850.
— —	*Bronn.* Lethæa Geognost. Kreidegebirges, p. 191, pl. xxix, fig. 18, *a*, *b*, 1857.
— —	*Quenstedt.* Handbuch der Petrefak., p. 583, 1852.
ECHINOCONUS —	*d'Orbigny.* Revue et Mag. de Zoologie, p. 20, 1854.
— PYRAMIDALIS,	*d'Orbigny.* Idem.
— ANGULOSUS,	*d'Orbigny.* Idem.
GALERITES ALBOGALERUS,	*Forbes.* In Morris's Catalogue of Brit. Foss., 2nd ed., p. 80, 1854.
ECHINOCONUS —	*Cotteau.* Ech. Foss. Pyrénées, Bulletin Soc. Géol. de France, 2e sér., t. xiii, p. 258, 1856.
— CONICUS,	*d'Orbigny.* Palæontol. Française ter. Crétacés, t. vi, p. 513, pl. 996, 1856.
— SUBPYRAMIDALIS,	*d'Orbigny.* Idem, pl. 1000, p. 530.
GALERITES ALBOGALERUS,	*Pictet.* Traité de Paléont., pl. xcv, fig. 12, 1857.

GALERITES ALBOGALERUS, *Desor.* Synopsis des Échinides Foss., pl. xxv, 1857.
ECHINOCONUS CONICUS, *Cotteau.* Échinides du Départ. de la Sarthe, pl. 47, figs. 1—3, 1860.

Diagnosis.—Test much elevated, conoidal, larger anteriorly than posteriorly; slightly angular and rounded at the border; base flat; single inter-ambulacrum tumid and recurved; vent large, oval, infra-marginal; mouth-opening central, periostome decagonal, armed with five pairs of dentiferous jaws; ambulacra straight, narrow, doubly lanceolate; pores small, unigeminal, in oblique pairs, which become trigeminal near the periostome; interambulacra wide, angular; tubercles on both areas small, homogeneous; granules abundant, unequal, sometimes elongated and prominent; apical disc small, quadrangular, very solid.

Dimensions.—Height, one inch and five tenths; latitude, one inch and four tenths.

Description.—I recognise three well-marked varieties of form in this Urchin, which have been described as distinct species by different systematic authors: these are, according to my reading of the matter, as follows :—

FORMA *α*. *Conica.*—This may be regarded as the normal form, and as such it is figured as the type of the species.

FORMA *β*. *Pyramidalis.*—Desor, 'Monographie des Galérites,' Pl. I, figs. 1—3; d'Orbigny, Paléontologie Pl. 1000, figs. 5—7. A small test, with pyramidal elongation of the vertex.

FORMA *γ*. *Angulosa.*—Desor, 'Monographie des Galérites,' Pl. 4, figs. 5—7, a depressed, elongated, and angular variety of *Conica*.

Description.—This is the most typical of all the Echinoconi, and has been well figured and described by most classical authors who have described the different forms of this genus. It is the true *Echinoconus vere conicus* of Breynius, 1732; two years later it was figured and described as *Conulus albo-galerus* by Klein, on account of its supposed resemblance to the white caps worn by the priests of Jupiter. Lang figured it in 1708 as *Echinometritis* in his 'Historia Lapidum figuratorum Helvetiæ,' and Bourget in his 'Traité de Petrifactions,' as the *Echinite conoide*, whilst Lamarck made it the type of his new genus Galerites, reserving for it the specific name *albo-galerus*, given by Klein, by which it has been known to the present time.

The general form of this Urchin is conical, varying in different specimens from a tall pyramid, with very steep sides, to a short one with inflated walls; the base is flattened, its circumference slightly pentangular, the greatest width corresponding to the region of the antero-lateral ambulacra; the basal angle is more or less rounded, and the single inter-ambulacrum tumid and recurved.

The ambulacral areas are doubly lanceolate, and built up of minute plates, which in the upper part of the area are often cuneiform in shape, irregular in size, and some-

times separated from each other by small accessory pieces; near the ambitus they have a more regular shape, as seen in Pl. L, fig. 1 *d*. All the plates are narrow, four or five corresponding in depth to one inter-ambulacral plate. In the large specimen drawn in Pl. XLIX, fig. 3, there are fifteen plates in each dorsal inter-ambulacral column between the angle of the disc, so that in this specimen, in the same space, there are seventy-five plates in each half of an ambulacral area; there are four rows of primary tubercles in the widest part of the area, which have a zig-zag arrangement, the two inner rows, which are the most irregular, disappear near to the middle of the base, and about the upper fourth of the dorsal surface. The poriferous zones are very narrow, the pores unigeminal and oblique, six pairs being often opposite one large plate; near the mouth they form sets of triple oblique pairs, as in the example (fig. 5), magnified four times; from several specimens before me in different stages of weathering, I have ascertained that a small cuneiform plate is apportioned to each pair of holes; this plate appears to have been formed of two halves, so as to embrace the tubular feet; the plates, therefore, of the poriferous zones are not perforated for the soft parts, but have, in fact, grown around them in the process of development.

The inter-ambulacral areas are three times the width of the ambulacral at the ambitus (Pl. L, fig. 1 *d*); they are formed of large plates, each supporting from 10 to 14 primary tubercles, arranged in irregular horizontal rows, which sometimes assume an hour-glass-shape-like disposition; each of these tubercles is spiniferous (fig. 1 *f*), and is encircled by a smooth depressed areola; the boss is large, mammillated, and crenulated at the summit, and the small round head is perforated; those at the base are larger, and form more regular horizontal rows; when examined with an inch object-glass they present the appearance shown in fig. 1 *f*. The inter-tubercular surface is covered with rows of microscopic granules (fig. 1 *d*, *e*, *f*); the tubercles on the upper surface all supported short spines, which are sometimes seen *in situ*, those at the base are large, about one fifth of an inch in length; they are slender, tapering, smooth, and covered with fine longitudinal lines, which are delicately serrated near the summit, the stem is enlarged at the base, where it is encircled by a crenulated collar (fig. 3). Dr. Bowerbank made a microscopic examination of the spines of *Echinoconi* in his collection, and found that the dorsal spines of *E. conicus* differed from those of *E. subrotundus* in being thickened at the base, and set on tubercles as it were sessile, instead of being shortly pedunculated, as they are in the latter species.

The minute moniliform spines of *E. conicus*, according to Dr. Bowerbank, are $\frac{1}{133}$ of an inch in length, and of equal diameter (fig. 4). Three were accurately measured, and all were as nearly as possible of the same size and proportions; they were all perfectly smooth.

The mouth-opening is small and central (Pl. L, fig. 1 *b*); the periostome is decagonal (fig. 5), and armed with a dental lantern: this fact was first discovered by Mr. Charles Stokes, F.G.S., and described by him in the 'Geological Transactions;' since that time

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MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART SEVENTH.

ON THE ECHINOCONIDÆ, ECHINONIDÆ, ECHINOBRISSIDÆ, ECHINOLAMPIDÆ, AND SPATANGIDÆ.

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other specimens exhibiting the jaws have been discovered. The teeth are small, smooth, white, lanceolate, triangular, each consisting of a concave lamina, terminating below in the dental point, and strengthened by a prominent ridge behind (fig. 6).

The base is flat, and both areas are covered with much larger tubercles than those developed on the dorsal surface; they are arranged in irregular concentric rows around the peristome; the single inter-ambulacrum is elongated posteriorly, and more tumid towards the border, which is sometimes rostrated and recurved (Pl. XLIX, fig. 2 and fig. 4, and Pl. L, fig. 1 and fig. 2). In this portion the vent opens; this aperture is one third larger than the mouth, and broadly elliptical in a longitudinal direction; its margins are thick and elevated, and appear to have supported an anal membrane. The vent is marginal in a majority of specimens, and is rarely seen above the border; most frequently it cuts that angle obliquely (Pl. L, figs. 1 and 2).

The apical disc (Pl. L, fig. 1 *e*) is quadrangular, and formed of four perforate and one small imperforate ovarial plates; the right antero-lateral is the largest, and extends into the centre of the disc, its surface supports the madreporiform body; the five ocular plates are small cordate elements, closely wedged in the angle between the ovarials.

Affinities and Differences.—This typical species differs from its congeners in its form, which is always conical or pyramidal; the base is flat and sub-pentangular, and the single inter-ambulacrum is posteally produced, being somewhat tumid and recurved. These characters readily distinguish it from *E. castanea*. The straight, slightly inclined sides, the acute ambital angle, and flat base, form a good diagnosis between it and *E. subrotundus*, which has convex sides, a rounded ambital border, narrow base, and small inter-ambulacrum; the conical form, small tubercles, and large vent distinguish it from *E. abbreviatus*.

Locality and Stratigraphical Position.—This species is found in abundance in the white Medial Chalk of the English Cretaceous districts. It is very Common in the south; fine specimens are obtained at Gravesend and other localities in Kent, and at Swaffham, in Norfolk. Specimens showing the dentiferous jaws are in the collections of Mr. Stokes, Dr. Bowerbank, and my kind friend the Rev. T. Wiltshire, F.G.S.; to whom I am indebted for the figured specimen.

Foreign Localities.—In France, according to M. Cotteau, it is found in l'Étage Sénonien, at Meudon, near Paris, near Sens, Villeneuve-le-Roi, and Charny, Yonne; Beauvais and Roquemont, Oise; Chartres, Eure-et-Loire; Vernonnet and Pinterville, Eure; Bains-de-Rennes, Aude; the environs of Aix-la-Chapelle, and in the Island of Ruëgen.

ECHINOCONUS ABBREVIATUS, *Desor*. Pl. LII, fig. 2 *a—i*; Pl. LIII, fig. 1.

CONULUS GLOBULUS,		*Klein*. Nat. dispositio Echinodermatum, p. 25, tab. xiii, c, D, E, F, var. *a*, *Wagricus*; tab. xiv, *c, d, e, f*, var. *β*, *Gedanensis*, 1734.
—	NODUS,	*Klein*. Idem., tab. xiv, *g, h, Gottlandicus*, 1734.
—	BULLA,	*Klein*. Idem., tab. xiv, *i, k, Gedanensis*, 1734.
ECHINITES VULGARIS,		*Leske* (pars), *Klein*. Echin., tab. xiii, C, D, E, F; tab. xiv, C, D, E, F, 1778.
—	—	*Gmelin*. Syst. Naturæ, p. 3182, 1789.
—	—	*Bruguière*. Encycl. Méthod., tab. 153, figs. 6, 7, 1791.
GALERITES	—	*Lamarck* (pars). Syst., p. 347, 1801.
—	—	*Lamarck*. Animaux sans Vertébres, t. iii, p. 20, 1816.
ECHINITES	—	*Schlotheim*. Die Petrefakten, p. 320.
GALERITES TRUNCATUS,		*Defrance*. Dic. Sc. Nat. Galérites, t. viii, p. 87.
—	VULGARIS,	*Deslongchamps*. Encycl. Méthod., p. 431, 1824.
—	—	*Goldfuss*. Petrefacta Germaniæ, tab. xl, fig. 20, 1829.
—	—	*Woodward*. Geology of Norfolk, pl. v, fig. 2, 3, 1833.
—	—	*Blainville*. Manuel d'Actinologie, p. 222, 1834.
—	PYRAMIDALIS,	*Desmoulins* (pars). Études sur les Échinides, p. 248, 1837.
—	ABBREVIATA,	*Desor*. Monographie des Galérites, tab. iii, figs. 9—17, p. 20, (*non* Lamarck), 1816.
—	—	*Agassiz* and *Desor*. Catal. raison., p. 90 (modèles s. 65, s. 70).
—	VULGARIS,	*d'Orbigny*. Prod., t. ii, p. 272, 1847.
—	ABBREVIATUS,	*Forbes* (pars). Mem. Geol. Soc. Survey, decade iii, pl. viii, fig. 5, 1850.
—	—	*Bronn*. Lethea Geognost. Kreid., p. 192, pl. xix, fig. 17, 1854.
—	—	*Desor*. Synopsis des Échinides Foss., p. 184, 1858.
—	—	*Morris*. Catal. of British Fossils, 2 ed., p. 80, 1854.
—	—	*d'Orbigny*. Revue de Zoologie, p. 20, 1854.
ECHINOCONUS GLOBULUS,		*d'Orbigny*. Paléontol. Française, t. vi, tab. 999, p. 522, 1855.

Diagnosis—Test thick, elevated, conoidal or globular, margin almost circular, not angular; wider near the anterior third; base flat, rounded at the circumference; single inter-ambulacrum narrow, tumid, and recurved at the border; vent prominent, inframarginal; primary tubercles surrounded by deeply concave areolas; miliary granules large and thickly set on the inter-tubercular spaces.

Dimensions.—Height, one inch and one tenth; length, one inch and four tenths; latitude, one inch and three tenths.

Description.—The attempt to make out the history of this Urchin has proved a perplexing and unsatisfactory task, inasmuch as the type-specimens figured by Klein were

siliceous moulds without any portion of test attached thereto, and of these he made three species, *Conulus globulus*, *C. nodus*, and *C. Bulla*. His learned commentator, Leske, in his 'Additamenta ad Kleinii Dispositionem Echinodermatum,' p. 165, groups them all into one species, which he described under the name *Echinites vulgaris*, and remarks, "Interim hae differentiæ si hæc corpora petrefacta, quæ plerumque nuclei tantum *Echinitarum* sunt, attente contemplor, mihi magis videntur a mutatione, cum in petram converterentur Echini naturales, pendere, quam veram diversitatem specierum indicare. Itaque etiam *Nodum* et *Bullam* Klenii, § 53, 54, ad varietates refero. Prout enim testa vel plus vel minus comprimeretur, eo vel obtusa, vel conica magis nascebatur figura. In multis speciminibus vertice obtuso, hic vi externa quasi impressus videtur." Lamarck, in his 'Système,' 1801, and in 'Animaux sans Vertèbres,' 1816, followed Leske, and cites the Tabs. XIII and XIV of Klein's work as types of *E. vulgaris*.

Leske, in his 'Additamenta,' p. 166, describes another large mould, which he regards as a variety of *Echinites vulgaris*, and figures the same. In Tab. XL, figs. 2 and 3, of this specimen he observes, "Singularis et notatu digna varietas, tam propter brunum colorem; quam propter insignem magnitudinem est ea, Tab. XL, Van Phelsum hanc iconem interrogando cum Klenii Tab. XIII, G, H, comparat. Singulares etiam rugæ et lineæ eminentes in areis conspiciuntur. *Ambulacra* singula biporosa fuisse videntur: *os* parvum; *anus* oblongus; ambitus testæ est circularis."

Lamarck, in his 'Animaux sans Vertèbres,' tom. iii, p. 20, describes this mould as a new species under the name *Galerites abbreviatus*, and cites Leske's figure as its type, but we are left in ignorance of its true specific characters, as the test is entirely wanting.

Schlotheim, Deslongchamps, Goldfuss, d'Blainville, Desmoulins, and Milne-Edwards, in their several works, have followed Lamarck.

Professor Desor, in his 'Monographie des Galerites,' first gave capital figures in Tab. III, fig. 9—17, and a concise description of a large Urchin with the test entire, and interior moulds of the same from the collection of M. de Luc. The specimens were collected from the detritic sands of Stada, in North Germany; he considers these moulds to be the same species which Klein figured as *Conulus globulus*, *C. nodus*, and *C. nodosa* in his 'Dispositio Echinodermatum,' Tab. XIII, fig. D—H. The specimen with the shell was a unicum and has been valuable as helping us to a knowledge of the moulds which have occasioned so much confusion in our synonymy.

Mr. S. Woodward, Sen., in his 'Memoir of the Geology of Norfolk, has figured two varieties of this Urchin as *Galerites vulgaris*, α, β. The specimens Mr. Bone has drawn for this work were obtained from the same chalk pits as those from whence Mr. Woodward's fossils were collected, and these Norwich specimens agree so well with Desor's figure that there is no doubt about their identity with M. de Luc's Urchin.

M. d'Orbigny, in his 'Palæontologie Française,' described and figured this species under the name *Echinoconus globulus*, Klein, which, I admit, would have been correct in accordance with the principle of priority which has guided our nomenclature of species

had only one species been so named, but as Klein described three species out of what now appears to be mere varieties of one form in my judgment it is wiser, for the sake of clearnesss and precision, to avoid the revival of either of his names, as it is uncertain to which variety the name *globulus* should be strictly applied.

In order to define accurately this species, I have determined to adopt Professor Desor's figures and description as the type retaining the specific name *abbreviata* without reference to the mould to which it was first applied.

The test is round, not angular at the border, moderately elevated; convex or subconoidal, a little wider anteriorly, its greatest latitude being across the antero-lateral ambulacra, the sides are unequally inflated, the posterior half being more protuberant than the anterior half, owing to the apical disc being excentral and situated a little forwards (Pl. LII, fig. 2 *c*, Pl. LIII, fig. 1); the base is flat, the mouth-opening small, round, and prominent; the vent larger and opening into a recurved prominence formed by the single inter-ambulacrum (Pl. LII, fig. 2 *b*, *d*).

The ambulacral areas are narrow (Pl. LII, fig. 2 *e*) and built up of a column of small plates, of which four correspond in height to one inter-ambulacral, the outer border of each pair of microscopic pedal plates are united, and in each of these a pair of pores are set obliquely. The anatomy of the pedal plates forming the poriferous zones is more satisfactorily exposed in the specimen now under examination than I have hitherto seen them, and clearly shows that the poriferous zones are a portion of the test distinct from the plates forming the inter-ambulacra and ambulacra between which they are interposed, each pair of holes being formed, for the passage of the tubular feet, by the growth of a pair of plates around the exertile pedal suckers.

The inter-ambulacral areas are three times the width of the ambulacral; on each plate are three horizontal rows of tubercles, four or five in each row (fig. 2 *e*), each is surrounded by a sunken areola, encircled by granules; the boss is crenulated, and the summit of the tubercle perforated (fig. 2, *g*, *h*). The entire surface of the plates is covered with granules much larger and more numerous than in any other *Echinoconus*.

The base is flat or slightly concave, and the border rounded; the single inter-ambulacrum convex, prominent, and recurved at the margin, where the circular vent opens (fig. 2 *b*, *d*); the mouth-opening is small and central, the peristome feebly diagonal with an elevated border at the circumference.

The apical disc is small, and its plates so intimately soldered together that few specimens show the sutures (fig. 2 *i*); the disc is excentral and inclined forwards, as the slope from the disc to the anterior border is shorter than the slope from disc to the posterior border; this is owing to the great development of the single inter-ambulacrum and the prominence of the basal portion of that area (see Pl. LII, fig. 2 *c*; and Pl. LII, fig. 1). The two pairs of ovarial plates are small, their holes very large (fig. 2 *i*); and the

small single plate is imperforate; the spongy portion of the madreporiform body is small, and the surface of the other plates closely covered with granules.

One remarkable feature in the structure of this test consists in the size, number, and prominence of the miliary granules, which cover the inter-tubercular spaces and form on the sides and upper surface of well-preserved specimens a thin incrustation which coats the plates and makes the tubercles on the sides appear as punctured depressions rather than elevations of the test. Pl. LII, fig. 2 *e*, is a drawing of a portion of both areas with the zones magnified four diameters, taken from the side of the test; the inter-ambulacral plates support three rows of tubercles, four or five in each, which are situated in a depression surrounded by an areola, and have some of their bosses crenulated and summits perforated (fig. 2 *g*, *h*). The ambulacra have four rows of similar tubercles and a like abundance of close-set granules on the surface of their plates. The tubercles on the basal plates are more numerous, the areolas wider, and the granules in a great measure absent from this region of the test (fig. 2 *f*) where these large basal plates are situated, they are drawn, magnified four diameters.

The mouth-opening is very small (fig. 2 *b*), about one third less than the vent; the peristome is nearly circular, thickened and prominent like the vent, the microscopic plates of the inter-ambulacra being narrow and piled on each other produce the rounding and thickening of the peristome; the pores in the zones are unigeminal around the opening. One remarkable specimen in my collection enables me to make these detailed observations on the minute anatomy of the test of *E. abbreviatus*.

Affinities and Differences.—This species resembles *E. subrotundus* in the elevation of the upper surface and inflation of the lateral parts. A comparison, however, of the profiles of both species, as given in Pl. LII, fig. 1 *c*, and fig. 2 *c*, and Pl. LIII, fig. 1 and fig. 2 *c*, will show at a glance several distinguishing characters, the excentricity forwards of the apical disc, the shortness of the anterior slope, as compared with the greater length of the posterior, and the prominence and recurvation of the single inter-ambulacrum. In *E. subrotundus* the tubercles are larger and more numerous and the miliary granules smaller and fewer, whilst the reverse forms one of the specific characters of *E. abbreviatus*; the tubercles are small and sparse, and appear sunk in the test by the great development of the miliary granulation which forms a thin coating on the lateral and upper portions of the plates. In Pl. LII both species are admirably drawn, and the minute anatomy of the tests displayed, so that a careful examination of the figures, will place the affinities and differences between these confluent forms more clearly before the eye of the student, than the most elaborate description could convey to the mind.

Locality and Stratigraphical Position.—All the examples of this species that I have examined were collected from the Upper Chalk at Harford Bridge, Trowse, and Trimmingham, Norfolk, where it is known as a leading fossil of the Norwich Chalk.

ECHINOCONUS GLOBULUS, *Desor*. Pl. XLIX, fig. 1 *a—g*.

GALERITES GLOBULUS, *Desor*. Monographie des Galerites, tab. iv, figs. 1—4, p. 18, 1842.
— — *Forbes*. In Morris, Catalogue of Brit. Foss., 2nd ed., p. 80, 1854.

Diagnosis.—Test small, nearly globular; base narrow, border rounded; vent elliptical and supra-marginal; inter-ambulacral plates sparsely covered with primary tubercles.

Dimensions.—Height, six tenths of an inch; length, eight tenths; latitude, seven tenths.

Description.—The small test figured in our Pl. XLIX was always considered to be a distinct species by the late Dr. Woodward; it is identical with the form first described and figured by Professor Desor, in his 'Monograph on the Galerites;' the specimen, in fact, which served as the type of Desor's figure belonged to the collection of M. de Luc, who obtained it from the English White Chalk; at first sight it appears to be a young specimen of *E. subrotundus;* a closer examination, however, shows it differs in essential points from that form. The test is slightly elongated, and is nearly globular in consequence of the narrowness of the base, and the rounding of the border; the posterior carina is not prominent, the vent is elliptical and quite supra-marginal, but in consequence of the rounding of the border this aperture is visible both from the base and upper surface. The ambulacral areas are built of very narrow plates and have four rows of tubercles arranged obliquely on the area, one tubercle from the inner row alternating with a tubercle on the outer row; the poriferous zones are very narrow, the pores unigeminal and oblique, six pairs being opposite one large plate (fig. 1 *e*).

The inter-ambulacral areas are twice the width of the ambulacral; each of the plates supports five or six tubercles arranged in quincuncial order, and the inter-tubercular surface is covered with microscopic miliary granules, of which a capital sketch is given in fig. 1 *e;* at the border and base the granules form regular circles around the tubercles, as seen in fig. 1 *g*. Both these drawings are magnified six diameters.

The apical disc is large and well developed in this small Urchin (fig. 1 *f*); the right antero-lateral ovarial is the largest plate in the disc and extends into the centre; it is covered with the spongy body, and the other three ovarials forming the two pairs are small and of the same size; they are perforated near their apices, and the small posterior single ovarial is imperforate; the five ocular plates are all well perforated.

The mouth-opening is small and central, and the peristome less in diameter than the supra-marginal elliptical vent.

Affinities and Differences.—The globular shape of this Urchin resembles some forms

of *E. subrotundus*, of which it may be only a variety; it has, however, fewer tubercles on the inter-ambulacral plates, and the vent is much higher up on the test than in that species. Its globose form presents a remarkable contrast to the conical *E. conicus*, the elongated *E. castanea*, and the recurved posterior base of *E. abbreviatus*.

Locality and Stratigraphical Position.—This very rare species is found in the Upper White Chalk with flints at Gravesend and in Kent. The test I have figured is contained in the British Museum.

Genus—Holectypus, *Desor*, 1847.

Discoides (pars), *Klein*, 1734.
Echinites (pars), *Leske*, 1778.
Galerites (pars), *Lamarck*, 1816.
Discoidea (pars), *Gray*, 1835.

The Genus *Holectypus* was established by M. Desor for the reception of those Discoideæ which are deprived of ribs or projecting processes on the inner wall of the test. The species referred to this group constitute one of the oldest types of the Echinoconidæ, and are met with chiefly in the Oolitic rocks. They form, according to the views of the late Professor Forbes, "a section or sub-genus of the *Galerites*, more valuable on account of their palæontological merits, and limited distribution in time, being in the main characteristic of the Oolitic period, than for the zoological importance of the character of their organization, which are rather transitional than distinctive."

The test is thin, circular, or sub-circular, more or less hemispherical, conical, or sub-conical, always tumid at the sides, and flat or concave at the base.

The ambulacral areas are narrow, straight, and lanceolate, with six or eight rows of small tubercles, of which the marginal series only extend from the base to the apex.

The poriferous zones are narrow, and the pores are unigeminal throughout.

The inter-ambulacral areas are three times the width of the ambulacral; the large pentagonal plates support numerous, small, perforated tubercles, which are very regularly arranged in vertical and concentric rows. They are raised on bosses with crenulated summits and surrounded by ring-like areolas; numerous minute granules are scattered over the surface of the plates and form circles around the tubercles.

The mouth-opening is circular and situated in the centre of the base; the peristome is divided by obtuse notches into ten equal lobes. The organs of mastication consisted of five jaws, which are preserved *in sitú* in one specimen I collected from the Forest Marble of Wilts.

The anal opening is large, inferior, infra-marginal, rarely marginal, sometimes occupying the entire space between the mouth and the border.

The apical disc is nearly central and vertical, composed of five ovarial and five ocular plates; the right antero-lateral ovarial is much the largest and extends into the centre of the disc; it supports a prominent, convex, madreporiform body. In all the Oolitic species the anterior and posterior pairs of ovarials are perforated, and the single plate imperforate; whilst in all the Cretaceous species the five ovarial plates are all perforate, and the five ocular plates are small, triangular bodies, with marginal perforations (fig. 1 *i*).

The internal moulds of *Holectypus* want those depressions occasioned by ribs projecting from the inner walls of the test which so well characterise the genus *Discoidea*.

The spines are short, with a smooth head and milled ring, and they have the surface sculptured with fine longitudinal lines.

Holectypus is distinguished from *Echinoconus* by having a larger mouth and vent, a concave base, and a less elevated dorsal surface; and from *Discoidea* in having tumid sides, a larger mouth and vent, and the absence of ribs from the internal walls of the test.

The small crenulated tubercles and basal vent, with the absence of any aperture in the upper surface of the inter-ambulacrum, distinguishes *Holectypus* from *Pygaster;* and the want of a longitudinal valley in the inter-ambulacrum separates *Holectypus* from *Hyboclypus* and *Galeropygus*.

The Genus *Holectypus* is most abundant in the Oolitic rocks; the Cretaceous rocks of France contain seven species: one is special to the Neocomian, one to the Aptien, three to the Cenomanian, and two to the Turonian stages. I now add a new species from the Chloritic Marl of England, and the first of this genus from the chalk found in the British Islands.

The Genus *Holectypus* forms two natural groups, both organically and stratigraphically distinct from each other. The apical disc in one group has only four of the ovarial plates perforate; in the second group all the five ovarials are so. The species with the four perforate ovarials are all Jurassic, and those with the five perforate ovarials are Cretaceous.

HOLECTYPUS BISTRIATUS, *Wright*, sp. nov. Pl. LXV, fig. 3 *a*, *b*, *c*.

Diagnosis.—Test sub-circular, sub-conoidal, depressed on the upper surface, and flattened at the base; ambulacra lanceolate, with four irregular rows of small tubercles; poriferous zones straight, narrow, with a smooth nude band extending from the disc to the border on the inter-ambulacral side of each zone. Inter-ambulacra wide, plates narrow, with horizontal rows of small tubercles on each, apical disc small.

Dimensions.—Height eight tenths of an inch; breadth one inch and eight tenths of an inch.

Description.—This rare Urchin was collected many years ago from the Chloritic Marl, near Chard, by Mr. Weist, and kindly communicated for this work. It was long considered to be a depressed variety of *Discoidea cylindrica*. In developing the specimen, however, I displaced a portion of the test, which disclosed the inner surface and the mould, and it then became evident that the Urchin was not a *Discoidea*, but a true *Holectypus*, as it had none of the internal ribs at the ambitus which distinguish *Discoidea;* it is the first *Holectypus* that has been recorded from the Cretaceous rocks of England.

The test is sub-circular, thin at the ambitus and depressed on the upper surface (fig. 3 *b*); the ambulacral areas are lanceolate, with four or six rows of small tubercles disposed in a zig-zag manner on alternate plates of the area which are very narrow, five of them in vertical height being equal to one inter-ambulacral plate. The poriferous zones are narrow, the pores small, and unigeminal, one pair of pores corresponding to one ambulacral plate (fig. 3 *c*) magnified twice.

The inter-ambulacral areas at the ambitus are nearly three times the width of the ambulacra; the columns are built of narrow plates, each supporting a horizontal row of small tubercles, seven to eight in a row near the ambitus and fewer up the sides, each tubercle is surrounded by a narrow areola, the boss of which is crenulated and the summit perforated. The only specimen I have seen is the one under examination; unfortunately, the surface of the test is so much rubbed that its minute structure can only be made out by selecting those parts of the plates which are best preserved for careful study with the glass. The tubercles are very small and numerous, and the horizontal rows they form fill up the greater portion of the surface of the plates, so that the number of miliary granules is inconsiderable. On each side of the inter-ambulacra, separating the tubercular surface from the poriferous zones, two smooth nude bands extend from the ambitus to the disc. These naked calcareous ribbons are very well seen on one of the areas, and this bistriated structure forms a specific character of some value and from which the specific name is derived.

The apical disc is small, and the five ovarial plates are all perforated; the spongy body is much rubbed and the ocular plates so blended with the other elements that their individual character cannot be seen.

The base is covered with the matrix, which adheres so firmly to the test that it is impossible to effect its separation from the surface without at the same time removing the shell. The anatomy of this region is, unfortunately, at present unknown.

Affinities and Differences.—This species very much resembles *Holectypus Cenomanensis*, Guéranger both in the general outline of the test, the smallness of its tubercles, and in the manner they are disposed on the plates. It is found likewise in nearly the same horizon of the Cretaceous rocks. The only difference I can detect is the presence of the nude ribbon-like bands on the outer side of the poriferous zones, no indication of which is given in M. Cotteau's beautiful and carefully drawn figures.

Locality and Stratigraphical Position.—Collected from the Chloritic Marl near Chard, with *Catopygus columbarius*, *Pyrina Desmoulinsii*, *Cottaldia Benettiæ*, and other Upper Greensand forms.

Family 7.—Collyritidæ, *d'Orbigny*, 1853 (not yet found in British Cretaceous strata).

Family 8.—Echinonidæ, *Wright*, 1856.

Test thin, oval; poriferous zones narrow, meeting at the apical disc; pores unigeminal; tubercles of both areas nearly equal in size, but neither perforated nor crenulated; spines stout, subulate. Mouth-opening nearly central, irregularly pentagonal and edentulous. Vent oblong or pyriform, basal or marginal, closed by anal plates; apical disc nearly central, four ovarial plates perforated, one imperforate. Oculars microscopic, tubercles small and imperforate.

The existing forms belong to the genus *Echinoneus* of Van Phelsum, instituted under the Dutch name *Egelschuitze*, and adopted by Leske, Lamarck, Deslongchamps, De Blainville, and Desor, to include certain living species of small thin-shelled Urchins, with an oval form and a rounded and inflated border. The ambulacral areas are narrow and lanceolate; the poriferous zones depressed, and the pores small and unigeminal throughout; the upper surface is flattened, and the apical disc small and excentral; the two pairs of genital plates are perforated, and the single posterior plate is imperforate; the base is concave and curved from before backwards; the mouth-opening small, oblong,

oblique, and nearly central; the peristome entire and without auricles, and therefore edentulous. A diagnostic character of the family is the periprocte, which is basal and pyriform, about the same size as the peristome, and situated between the border and the mouth. The tubercles are small and numerous, disposed in regular series, and raised upon smooth circular elevations, with perforated summits; in this we discover another organic difference between the ECHINONIDÆ and the ECHINOCONIDÆ. The ECHINONIDÆ inhabit the seas of the Antilles, the Philippines, the Trinity, Cuba, Zanzibar, and New Zealand, and tests of the same species are found in a semi-fossil state in the calcareous tufa of Guadeloupe, Cuba, and Porto-Rico.

The fossil species are included in the genus *Pyrina*, which are all found in the different stages of the Cretaceous rocks.

Genus—PYRINA, *Desmoulins*, 1837.

PYRINA, GLOBATER, and NUCLEOPYGUS, *Agassiz*, 1837.

Test oval or round, depressed or globular, sometimes pentagonal or enlarged before and narrow behind. Under surface inflated and often depressed around the mouth-opening, which is oval, oblique, and inclined from the right to the left side; this aperture is nearly central, and destitute of lobes and auricles. The apical disc is small, compact, and nearly central; it is composed of four perforated genital plates, of which the right antero-lateral is the largest, extending into the middle, and supporting the small madreporiform body. The five small ocular plates are closely wedged into the angles formed by the genitals, all the elements of the disc being soldered together. The vent is oval and marginal, in general nearer the upper than the under surface. The poriferous zones form straight equal narrow linear depressions, all composed of simple pores in regular pairs extending from the peristome to the disc. The tubercles are mammillated and imperforate, larger at the under side, and the inter-tubercular surface of the plates is covered with a great number of granules.

Pyrina differs from *Echinoconus* in having in general an elongated form, the apical disc has only four genital plates, the mouth is oval, oblique and edentulous; the vent is marginal, and the tubercles are imperforate, whereas in *Echinoconus* the disc has five genital plates, the mouth is circular or slightly pentagonal, and provided with dentiferous jaws; the vent is basal or infra-marginal, and the tubercles are mammillated with crenulated bosses and perforated summits.

PYRINA DESMOULINSII, *d'Archiac*, 1847, Pl. LIV, fig. 2 *a—i*.

PYRINA DESMOULINSII, *d'Archiac*. Mém. de la Soc. Géol. de France, 2e série, tome ii, p. 297, pl. xiii, fig. 4, 1847.
— — *Agassiz* et *Desor*. Catal. raisonné, p. 92, Modèle T. 86, 1847.
— — *d'Orbigny*. Prodrome, t. ii, p. 178, Étage No. 651, 1847.
— — *Woodward*. Mem. of the Geol. Surv., Organic Remains, Decade v, pl. vi, fig. A, 1856.
PYRINA PRATTII, *Forbes*. Morris Catal. Brit. Foss., p. 88, 1854.
— DESMOULINSII, *d'Orbigny*. Paléontol. Française, tome vi, p. 467, pl. 981, figs. 7—11, 1855.

Diagnosis.—Test tumid, oblong; ambitus inflated; posterior border slightly emarginate; upper surface depressed; apical disc small, nearly central; base concave in the middle and pulvinated at the border; mouth-opening oval, oblique, and nearly central; periprocte elliptical, supra-marginal, nearer the upper than the under surface.

Dimensions.—Antero-posterior diameter one inch; height half an inch.

Description.—The test of this rare Urchin is oblong or elliptical, regular and symmetrical, depressed on the upper surface, inflated round the sides, and concave near the centre of the under surface. The summit is sub-central, nearer the anterior than the posterior border. The ambulacral areas are narrowly lanceolate; the poriferous zones are linear and depressed, and the pores minute, unigeminal, and placed in oblique pairs. In passing across the base the geminal pores become more and more oblique, until they fall into a single file and terminate around the peristome. The plates of both areas support a number of small equal-sized tubercles; in fig. 2 *e* is shown their mode of arrangement on the ambulacral and inter-ambulacral areas; they have a quincuncial disposition on the plates. The areal space around each is sharply defined, the tubercle is raised on a boss, and its summit is perforated. The intermediate surface of the plates is covered with a very fine microscopic granulation (fig. 2 *g*). The tubercles at the base are much more developed than those on the upper surface of the test. Fig. 2 *h* and fig. 2 *i* show the basal tubercles magnified; the areal space is deeply excavated out of the structure of the plate, and the tubercle is larger than those on the upper surface at fig. 2 *i*. A portion of the test near the mouth-opening is shown with the arrangement of the zones and the disposition of the tubercles in this region.

The mouth-opening is large, elliptical, elongated in the direction of its greatest axis, slightly oblique (fig. 2 *b*), and situated immediately beneath the organic summit.

The vent is elliptical, and placed in the middle of the posterior border (fig. 2 *d*), nearer the upper than the under surface (fig. 2 *a*).

The apical disc is small, and composed of four ovarial plates, of which the right antero-lateral is much the largest, and supports a spongy madreporiform body. All these plates are perforated (fig. 2*f*). The ocular plates, five in number, are small, and well wedged in between the ovarials.

Affinities and Differences.—The regular elliptical elongated form of *Pyrina Desmoulinsii*, with its flattened upper surface and pulvinated base, distinguish this species from its congeners. I have compared specimens obtained from the Étage Cénomanien of the environs of Tournay, Belgium, with specimens collected from the Chloritic Marl at Chard, and find them to be identical in all their details. It very much resembles *Pyrina ovulum*, which, however, is a smaller form, with a more inflated test, and the elliptical vent is situated near the dorsum. Compare fig. 2 and fig. 3, where the affinities and differences are well shown in the admirable figures in Pl. LIV.

It differs from *Pyrina lævis* in having a narrower test of a more regular elliptical figure, and wants the inflation of the anterior portion and the tapering of its posterior border.

Locality and Stratigraphical Position.—This rare Urchin was collected by Mr. Weist, in the Chloritic Marl, near Chard, and Mr. Pratt obtained another from the same locality and stratum, which has been beautifully figured in the 'Memoirs of the Geological Survey,' Decade v, pl. vi. The short description was from the pen of my old esteemed friend Dr. Woodward, to whom I forwarded all my materials when he was engaged in writing the text for the description of pl. vi of that Decade.

PYRINA OVULUM, *Lamarck*, sp. Pl. LIV, fig. 3 *a*—*h*.

NUCLEOLITES OVULUM,	*Lamarck.*	Anim. sans vert., t. iii, p. 37, 1816.
—	—	*Deslongchamps.* Encycl. Méthod., t. ii, p. 500, 1824.
—	—	*Defrance.* Dic. des Sc. Nat., t. xxxv, p. 213, 1825.
PYRINA	—	*Agassiz.* Cat. Syst., p. 7, 1840.
NUCLEOLITES	—	*Desor.* Mon. des Galerites, p. 26, pl. v, figs. 35—37, 1842.
—	—	*Agassiz* et *Desor.* Cat. rais. des Échinides, p. 92, 1842.
—	—	*d'Orbigny.* Prodrome, t. ii, p. 271, 1847.
—	—	*Morris.* Catal. of British Fossils, 2 ed, p. 88, 1854.
—	—	*Woodward.* Mem. Geol. Surv., Decade v, pl. vi, 1856.
—	—	*Cotteau.* Paléontologie Française, pl. 985, figs. 7—11, tome vi, p. 484, 1855.

Diagnosis.—Test small, inflated, depressed at the upper surface. Ambitus elliptical, base flattened, margin much inflated; mouth irregular, pentagonal, oblique, situated in the middle of the base; posterior border sulcated, vent elliptical, elevated near the upper surface, plates closely covered with small tubercles.

Dimensions.—Antero-posterior diameter four tenths of an inch; height three tenths of an inch.

Descriptions.—The test of this rare little *Pyrina* is oblong-oval, inflated, rounded before, and sulcated behind, for lodging the vent. In its longitudinal profile, fig. 3 *d*, the test is higher behind than before, and always more or less truncated, the upper surface is convex and slightly flattened, the under surface is convex and pulvinated, without a depression in the centre, the plates are covered with numerous small tubercles larger on the under surface, the areas are excavated to receive the boss, which carries a small perforated tubercle, fig. 3 *g* and *h*. The apical disc is small, composed of four perforated ovarial plates and five very minute oculars, fig. 3 *f*. The mouth opening is situated in the middle of the base, fig. 3 *c*, and forms an irregular pentagon with its long axis oblique. The vent is oval, situated in a sulcus high up in the posterior border, and the periprocte is much nearer the upper than the under surface, fig. 3 *b*, and fig. 3 *e*. The poriferous zones are extremely narrow, and appear like fine depressed lines on the surface of the shell.

Affinities and Differences.—This species differs from *Pyrina Desmoulinsii* in having the posterior border sulcated for the vent which occupies a higher position in this Urchin.

Locality and Stratigraphical Position.—It is said to have been collected from the lower chalk of Dorsetshire. In France M. Cotteau records it from l'Étage Sénonien, he collected it in that formation at Saint Christophe, and at Tours, Indre-et-Loire, and at Villedieu, Loir-et-Cher.

PYRINA LÆVIS, *Agassiz*, 1840. Pl. LIV, fig. 1 *a—e*.

GALERITES LÆVIS,	*Agassiz.*	Cat. Syst., p. 7, 1840.
—	— *Desor.*	Monographie des Galerites, p. 24, pl. iv, figs. 8—11, 1843.
—	— *Agassiz.*	Cat. rais., p. 91, Modèle 79, 1847.
—	— *d'Orbigny.*	Prodrome, t. ii, p. 272, 1847.
ECHINOCONUS	— *d'Orbigny.*	Revue Zoologique, p. 21, 1854.
PYRINA	— *Cotteau.*	Paléontol. Française, t. vi, p. 490, pl. 987, figs. 6—9, 1855.

Diagnosis.—Test subpentagonal, enlarged anteriorly and contracted posteriorly,

convex above, inflated at the sides and flattened below; vent large, supra-marginal, elliptical; mouth-opening central, opposite the disc; tubercles small, surface of the plates smooth.

Dimensions.—Anterior posterior diameter eleven twentieths of an inch; height seven twentieths of an inch.

Description.—This little Urchin appears to be a very rare form, as the example before me is the only specimen I have seen in English collections; the type specimen figured by my friend Professor Desor, in his Monograph on the Galerites belonged to M. Deshayes and was the only one known to him.

M. Cotteau has not seen the original, giving copies of Prof. Desor's figure of the test and quoting his description of its structure in his 'Paléontologie Française.' My specimen was collected several years ago from the Upper Greensand near Chute farm, Wilts, along with some fine examples of *Catopygus columbarius* and *Cottaldia Benettiæ*, so that there is no doubt of the horizon of the English specimen. The general outline of the test is indistinctly pentagonal, enlarged before and slightly narrower behind (fig. 1 *b* and fig. 1 *c*). The upper surface is convex, the sides inflated, and the base flat (fig. 1 *a*; fig. 1 *e*); its height is about one half the length of the test. The plates are covered with small tubercles, which are very indistinctly seen; those at the base are larger. The vent occupies the middle of the border; the periprocte is large, of an elliptical shape, and placed a little nearer to the base than the upper surface. The sur-anal carina is only slightly developed around the lower part of periprocte. The lower surface is nearly flat, with the margin round, and the small mouth-opening is situated in the middle of the base directly opposite the vertex.

Affinities and Differences.—This species is readily distinguished from *Pyrina Desmoulinsii* by its sub-pentagonal form enlarged before and contracted behind; its sides are likewise more inflated and the lower angle of the periprocte is nearest the base, whilst in *P. Desmoulinsii* the upper angle of that aperture is nearest the dorsal surface.

Locality and Stratigraphical Position.—I collected this Urchin from the Upper Greensand of Chute Farm, near Wilts, with *Catopygus columbarius, Cottaldia Benettiæ*, and other well-known forms of Urchins and Mollusca belonging to that stratum.

The type figured by M. Desor was obtained from the Cretaceous rocks of France, and as it was communicated to M. Desor by M. Deshayes without the indication of the formation from whence it was collected, we are unfortunately in ignorance of its stratigraphical position, and as M. Cotteau had not seen the specimen, he was unable to give an opinion on the matrix.

Family 9—Echinobrissidæ, *Wright*, 1856.

Test thin, circular, oblong, sub-pentagonal, or clypeiform, covered with microscopic perforate or imperforate tubercles, surrounded by excavated areolas; ambulacra narrow, enclosed by poriferous zones more or less petaloidal; pores set at different distances apart, and united by connecting sutures. Mouth-opening small, nearly central, pentagonal, edentulous, and in general surrounded by five lobes. Vent-opening in a sulcus in the upper surface of the single inter-ambulacrum, or in a marginal depression or basal portion thereof; apical disc small, with four perforate and one imperforate genital plate; ocular plates very small; madreporiform body extending into the centre of the disc. This family is extremely numerous in genera and species; two of its representative forms are still living—*Echinobrissus recens*, Edwards, in the Antilles, and *Cassidulus Australus*, Lamarck, in the Australian seas.

I include the following genera in this natural family:

Catopygus, *Agassiz.*
Clypeopygus, *d'Orbigny.*
Clypeus, *Klein.*
Echinobrissus, *Breynius.*
Phyllobrissus, *Cotteau.*
Botriopygus, *d'Orbigny.*
Trematopygus, *d'Orbigny.*
Rhynchopygus, *d'Orbigny.*
Cassidulus, *Lamarck.*
Caratomus, *Agassiz.*

Genus—Catopygus, *Agassiz*, 1837.

Nucleolites, *Lamarck, Goldfuss.*

Diagnosis.—Test oval or elongated, in general inflated, narrower anteriorly than posteriorly; upper surface convex, summit excentrical anteriorly; under surface flat or slightly convex, and rounded at the border; posterior half of the test much higher and wider than the anterior half; vent situated in the posterior border; periprocte small, round, or oval, placed high in a prominent projection of the inter-ambulacrum at the summit of a vertical truncation of the area. Mouth-opening small, situated nearer the anterior than the posterior border; pentagonal in form with equal elongated sides, having one angle anterior, and surrounded by five prominent lobes (Pl. LV, fig. 2 *h*); between the lobes a rosette is formed of five depressed leaves, crowned with minute granules and unequal

buccal pores, some double externally, others small internally. Ambulacra narrow, sub-petaloid, straight, more or less elongated, and open at the lower extremity; poriferous zones composed of an inner series of round pores, and an external series of elongated pores arranged in conjugate pairs (fig. 2 *g*); tubercles very small, raised on mammillated bosses (fig. 2) in many horizontal lines on the surface of the dorsal plates, those at the base being larger. Apical disc small, prominent, formed of four perforated ovarial plates and five microscopic oculars, the madreporiform body projecting from the surface (fig. 2 *f*).

Affinities and Differences.—*Catopygus* differs from *Clypeopygus* and *Echinobrissus* by its oval form, convexity of the upper surface, inflation of the sides, and flatness of the base, by its pentagonal mouth, with five prominent sides and rosette of pores between the lobes, and its small round periprocte opening high in a prominent vertical truncation of the single inter-ambulacrum.

The genus *Catopygus* appertains to the Cretaceous rocks, and is a very characteristic fossil in its different divisions. In the Gault or Albian stage of the Mediterranean basin *Catopygus cylindricus* has only hitherto been found.

In the Upper Greensand or Cenomanian formation *C. columbarius* prevails throughout the Anglo-Parisien and Mediterranean basins.

In the Lower Chalk or Turonian *C. Ebrayanus* is found.

In the Middle Chalk or Senonian eight species have been collected in France, where many of the beds of this division attain a development unknown in England, and contain a fauna of the most remarkable forms. The *C. sub-carinatus* and *elongatus* are found simultaneously in the Anglo-Parisian and Pyrenean basins, although *C. lævis, fenestratus, conformis, pyriformis, obtusus,* and *affinis,* are discovered only in the Parisian basin.

This genus, therefore, attained its greatest development in the seas which deposited the White Chalk with flints, and became extinct with the close of the Cretaceous epoch, as *Catopygus* is not found in the Tertiary rocks nor in the waters of the present time.

CATOPYGUS COLUMBARIUS, *Lamarck*, 1816. Pl. LV, fig. 2 *a—i*.

ECHINITES PYRIFORMIS, *Parkinson*. Organic Remains, vol. iii, tab. iii, fig. 6, 1811.
NUCLEOLITES COLUMBARIA, *Lamarck*. Anim. sans Vertèbres, t. iii, p. 37, 1816.
— — *Deslongchamp*. Encyl. Méthod., t. ii, p. 570, 1824.
— — *Defrance*. Dic. des Sciences Nat., t. xxxv, p. 313, 1825.
— CARINATUS, *Goldfuss*. Petrefacta Germaniæ, b. i, p. 142, pl. xliii, fig. 11, 1826.
— COLUMBARIA, *Blainville*. Dic. des Sciences Nat., t. lx, p. 188. 1830.

Catopygus carinatus,	*Agassiz.*	Prodrome Échinides, p. 18, 1836.
Nucleolites columbaria,	*Desmoulins.*	Études sur les Échinides, p. 356, 1837.
— carinatus,	*d'Archiac.*	Mém. Geol. Soc. de France, p. 180, 1837.
Catopygus —	*Bronn.*	Lethæ Geognostica, p. 613, 1837.
— —	*Milne-Edwards.*	In Lamarck, 2e éd., t. iii, p. 351, 1840.
Nucleolites columbaria,	*Ibid.*	Ibid., 344.
Catopygus carinatus,	*Agassiz.*	Cat. Syst., p. 4, 1840.
— —	*Roemer.*	Norddeuts-Kreide-Gebirges, p. 32, 1840.
Catopygus carinatus,	*Morris.*	Catalogue of British Fossils, p. 49, 1843.
— columbarius,	*d'Archiac.*	Mém. Soc. géol. France, p. 296, 1847.
— —	*Agassiz* et *Desor.*	Cat. raison., p. 100, Modèle R 71 1847.
— —	*d'Orbigny.*	Prod., t. i, p. 178, Étage 20, 1847.
Nucleolites carinatus,	*Forbes.*	Mem. Geol. Surv., Decade i, pl. 10, 1849.
Catopygus —	*Sorignet.*	Oursins de l'Eure, p. 43, 1850.
Nucleolites —	*Quenstedt.*	Handbuch der Petrefact., p. 586, pl. xlix, fig. 51, 1852.
Catopygus —	*Bronn.*	Leth. Geogn., 2 ed., p. 196, pl. 29[3], fig. 16, 1852.
— —	*Albin Gras.*	Catal. des Corps org. de l'Isère, p. 40, 1852.
— —	*Morris.*	Catal. of British Fossils, 2 ed, p. 74, 1854.
— columbarius,	*Cotteau.*	Pal. Franç. Ter. Crét., t. vi, p. 436, pl. 970, 1855.

Diagnosis.—Test oval or subrotund, contracted anteriorly, enlarged and truncated posteriorly, sides inflated, dorsal surface unequally convex, base nearly flat, ambulacra narrow, dorsal, subpetaloid and open below; inter-ambulacra wide, single inter-ambulacrum narrow, elevated, and truncated, vent round in the upper border, above the periprocte an obtuse carina which terminates in the projecting upper border of the vent; mouth-opening small, excentral nearer the anterior border, peristome surrounded by five prominent lobes and a rosette of pores between them. Apical disc excentral nearer the anterior border, the vertex in general behind the apex.

Dimensions.—I have selected six good typical forms showing the varying proportions of this species.

	1	2	3	4	5	6
Length .	1	$0\frac{11}{12}$	$0\frac{10}{12}$	$0\frac{9}{12}$	$0\frac{8}{12}$	$0\frac{7}{12}$
Height .	$0\frac{10}{12}$	$0\frac{10}{12}$	$0\frac{8}{12}$	$0\frac{6}{12}$	$0\frac{5}{12}$	$0\frac{7}{12}$
Breadth .	$0\frac{8}{12}$	$0\frac{7}{12}$	$0\frac{6}{12}$	$0\frac{6}{12}$	$0\frac{6}{12}$	$0\frac{7}{12}$

Description.—The table of synonyms exhibits the changing views of naturalists in respect to this beautiful Urchin. Goldfuss, who gave the first good figure of the species, cites, with doubt, its identity with *Nucleolites columbarius*, Lamarck, but the brief diagnosis in 'Hist. Nat. des Anim. sans Vert.,' taken in connection with the locality and stratum from whence it was collected, "les environs de Mans," so well known for its beautiful Upper-

Greensand fossils, has satisfied me, after a comparison of specimens in my collection from that locality with a series of type tests from the Upper Greensand of Wilts and Dorset, that the two Urchins appertain to the same species, and that Lamarck's name ought to be retained. *Catopygus columbarius*, it is true, assumes a considerable variation of form as regards the elongation, shortening, height, breadth, and inflation of the test, so that there is field enough for species-makers, who attach undue importance to these characters, to make several varieties out of a handful of specimens. These phases of form appear to me to have depended on the physical conditions which surrounded the life of the Urchin, and have nothing whatever to do with the specific characters I have pointed out in my diagnosis of the species.

The test is ovate or subrotund and always wider behind than before; the dorsal surface is tumid, varying in the degree of its elevation; in some specimens it is subdepressed and declines anteriorly, in others it is subconic and much elevated in the centre, the true apex being almost the apical disc, whereas, in general, that body is excentral and situated before the vertex, which is formed by the ridge of the single inter-ambulacrum. The sides are rounded and more or less inflated, and the posterior extremity is truncated more or less abruptly. A more or less developed obtuse central elevation extends along the ridge of the single inter-ambulacrum to the upper border of the vent, where it forms in many examples a prominent apiculated arch over the periproct, Pl. LV, fig. 2 *d*. In all the specimens I have examined this prominence exists, but its degree of development varies much. The ambulacral areas are narrowly lanceolate, limited to the dorsal surface, subpetaloid, and very uniform in their proportions in all the varieties. The single area and anterior pair are nearly equidistant from each other, but the posterior pair are more distant from the anterior pair, and are placed much closer together than the others and extend backwards. The number of pairs of pores in each zone is nearly equal, varying from twenty-eight to thirty in well-grown adult shells; the pores in the outer row are elongated and oblique, and in the inner pores are round and appear to be conjugated by fine oblique sutures. At the lower part of the petals the pores become smaller, and are set much wider apart as they pass round the border of the test and extend to the peristome. The ambulacral plates are narrow in the petaloid portion of the zones, and become much larger and broader beyond the petals; each plate has its pair of holes which can be distinctly traced in good specimens, and they form the true poriferous zones on the sides and base of the test. Pl. LV, fig. 2 *b*, *c*, *d*, *e*, shows these poriferous zones. Around the mouth the pairs of pores again form petals as on the dorsal surface, and they are here so arranged that they form ten short petaloidal ambulacra, forming rosettes around the mouth, and constructed like those on the dorsal surface. Fig. 2 *h* shows this structure extremely well in a drawing magnified six diameters.

The wide inter-ambulacral areas are formed of large oblong plates, the surface of which, as well as those of the ambulacra, are covered with minute moniliform tubercles, interspersed with microscopic granules. Fig. 2 *g* shows the arrangement of the tubercles

and granules on the ambulacral and inter-ambulacral areas magnified six times; and fig. 2 exhibits the more developed form the tubercles assume on the basal plates, and the manner they are encircled by rows of granules. It is only on very fine specimens, such as some I have obtained from the Chloritic Marl of Chard, that I have been able to see the surface anatomy of the plates, such as I have figured and described it; the Upper-Greensand fossils are spoiled by the matrix, and are quite unfit for such minute observations.

The small apical disc is, in general, excentral, and the madreporiform body occupies the centre, covers the plates, and forms a prominence; there are four perforated genital plates, and five distinct ocular plates (fig. 2 *b* and fig. 2 *f*). The two anterior genital holes are placed nearer together than the posterior pair.

The ventral surface is slightly convex, or nearly flat; the tubercles are much larger in this region, and exhibit the arrangement shown in fig. 2 *i*, where each tubercle rises on the surface of a rounded boss and is encircled by a ring of granules (fig. 2 *c*). The mouth-opening is excentral and nearer the anterior border, the peristome is pentagonal and surrounded by five prominent tubercles which form the termination of the inter-ambulacral areas (fig. 2 *c*). From the inter-lobular spaces ten short petaloid ambulacra proceed, and these collectively form rosettes around the peristome, as shown in fig. 2 *h*, where this structure is drawn magnified six diameters.

The vent opens in the upper portion of the truncated posterior border in a well-defined vertical area; it is oblong, and varies in size in different specimens, but is always small in proportion to the size of the test.

The periprocte is prominent, especially in the upper border, which, in some specimens, overhangs the vent in a beak-shaped fashion (fig. 2 *d*).

Affinities and Differences.—This species is found in the Upper Greensand or Cenomanian stage throughout the Anglo-Parisian and Mediterranean basins, and it is the only form of *Catopygus* hitherto collected in this stratum in England; its characters are so definite and distinct that there is no difficulty in distinguishing this species from its congeners.

Locality and Stratigraphical Position.—It has been collected from the Upper Greensand of Warminster and Chute Farm, Wiltshire; Hythe, Kent; and from the junction beds of Upper Greensand and Chalk-marl at Maiden Bradley, Wiltshire; and from the Chloritic Marl, near Chard, whence my best specimens were obtained. The foreign distribution of this species, according to M. Cotteau, is from the Cenomanian or 20th stage of d'Orbigny, the equivalent of the Upper Greensand of English authors. In France it is common at Mans, Coulaines, Saint-Calais, and Condrecieux, Sarthe; Villers, Trouville, Calvados; Havre, Seine-Inférieure; Gracé, Orne; Vierzou, Cher; Chinon, Indre-et-Loire; Fouvas and Bel-Air, near Rochefort, and other localities. In Belgium in the Tourtia of Tournay; in Westphalia at Essen on the Ruhr.

CATOPYGUS VECTENSIS, *Wright*, nov. sp. Pl. LV, fig. 1 *a—d.*

Diagnosis.—Test oblong, contracted posteriorly; dorsal surface flat and convex, elevated towards the narrow posterior border; sides inflated, base concave; ambulacra narrow, lanceolate, dorsal, subpetaloid, and open below; inter-ambulacra wide, single inter-ambulacrum narrow, slightly elevated; posterior border truncated; vent oblong, in the upper third; an obtuse elevation of the dorsal portion, bifurcating at the periprocte, sends down a carina on each side of the vent, which extends to the margin. Apical disc nearly central, four perforated genital plates; madreporiform body small, central.

Dimensions.—Length one inch; breadth eight tenths of an inch; height unknown.

Description.—This species has much resemblance to certain varieties of *Catopygus columbarius* but a careful comparison between it and the most allied forms of that species shows that *Catopygus Vectensis* possesses distinct characters of its own. It is, I believe, the oldest form of the genus *Catopygus* at present known. The outline of the test is nearly a regular oblong, rather more contracted posteriorly (Pl. LV, fig. 1 *a*, *b*). It is moderately elevated and a little higher at the posterior border (fig 1 *c*); the sides are inflated (fig. 1 *d*), and the base is concave; this portion of the test is partially covered by closely adherent matrix in the best specimen, and broken in the other, so I must speak with reservation regarding the specific characters of this region. The ambulacral areas are narrowly lanceolate (fig. 1 *b*, *d*), and the long subpetaloid poriferous zones extend over the dorsal surface, a character which is very well drawn in figs. 1 *a*, *b*, *c*, *d*; the traject line of the pores is indicated by the sutures in which they are placed, but the pores themselves cannot be satisfactorily made out in consequence of the imperfect preservation of the areal plates.

The inter-ambulacral areas are built of long plates; those on the upper surface had very small tubercles which appear to have been more developed at the base; the posterior single inter-ambulacrum has an elevated ridge on the mesial line which extends to the upper border of the vent (fig. 1 *o*), and then divides into two branches (fig. 1 *d*); which descend to the border, the whole forming a kind of miniature Gothic arch, having the oblong vent in its upper third (fig. 1 *c* and *d*).

The apical disc is nearly central (fig. 1 *b*), and lower than the vertex (fig. 1 *c*); it is small, has four genital holes drilled around a small central button-shaped madreporiform tubercle.

The mouth-opening is excentral and anterior; it is too much concealed by hard rock to be exposed without risking the fracture of the shell, so the anatomy of the peristome cannot be made out.

Affinities and Differences.—This species differs from *C. columbarius* in the following

characters :—The shell tapers behind, is not so elevated, has a flatter dorsal surface and less prominent central ridge in the inter-ambulacrum ; the apical disc is more central, and the contour indicates a flatter form with less inflated sides.

Locality and Stratigraphical Position.—This new species was collected by the Rev. T. Wiltshire, F.G.S., from the Lower Greensand (Neocomian) at Shanklin, Isle of Wight.

Genus—Clypeopygus, *A. d'Orbigny*, 1856.

Nucleolites (pars), *Agassiz, Desor, Cotteau.*
Echinobrissus (pars), *De Loriol.*
Catopygus (pars), *Agassiz.*

Diagnosis.—Test oblong, more or less depressed, upper surface convex, under surface concave, mouth-opening excentral, nearest the anterior border ; peristome surrounded by five rosettes of buccal pores, and separated by five prominent lobes, oral aperture regular, pentagonal, with equal sides and a prominent angle anteriorly. Vent small, situated in a deep groove with perpendicular walls and well-defined outline, extending nearly half way up the dorsal surface of the single inter-ambulacrum, ambulacra narrowly lanceolate, and subpetaloidal ; the anterior and posterior pairs, especially the latter, long and flexuous. The pores which compose the zones are sometimes unequal, the external series being more or less elongated in a transverse direction ; apical disc small, excentral, and composed of four perforated, and one imperforate genital plates, the right antero-lateral supporting the madreporiform body, which extends into the middle of the disc and forms a prominence there ; the five ocular plates are small and angled into the summits of lanceolate ambulacra. The tubercles are very small and set closely together on the upper surface (Pl. LVI, fig. 1 *f*), and larger on the under surface (Pl. LVI, fig. 3 *g*) ; they are all encircled by areal depressions and separated by minute granules.

This group was separated by M. A. d'Orbigny from *Echinobrissus* in consequence of the following characters, which he observed to be constant in all the species :—The large central polypiform madreporiform body ; the mouth-opening surrounded by five rosettes of pores, alternating with five well-developed buccal lobes ; and the anal sinus circumscribed and contracted.

The species are all special to the Cretaceous formations. M. d'Orbigny described and figured six from the Neocomian and two from the Albian stages, and I now add another form from the Neocomian of the Isle of Wight.

CLYPEOPYGUS FITTONI, *Wright*, nov. sp. Pl. LVI, fig. 1—3.

Test oblong, upper surface depressed, highest posteriorly; under surface concave; ambulacra narrow, lanceolate; poriferous zones subpetaloidal above and narrowly biserial on the sides and base; apical disc nearly central; vent-opening at the end of a narrow sinus with vertical walls; mouth-opening at the junction of the anterior with the middle third, peristome surrounded by five prominent lobes and five pairs of subpetaloidal pores, forming together a well-marked rosette.

Dimensions.—No. 1, length $1\frac{1}{10}$ inches, breadth 1 inch; No. 2, length $1\frac{1}{2}$ inches, breadth $1\frac{3}{10}$ inch.

Description.—The outline of the test is oblong, with the sides slightly compressed; the upper surface is convex, flattened at the anterior half, and gradually elevated towards the posterior third, which is the highest part of the test (Pl. LVI, fig. 1 *d*, fig. 3 *e*); from this point it bends abruptly down to the posterior border; Mr. Bones' capital figures in Pl. LVI make this character of the test far more intelligible than the most laboured description could effect.

The ambulacral areas are narrowly lanceolate, the antero- and postero-lateral pairs are long and flexuous, and the single area is short and straight; the poriferous zones (fig. 3 *f*) are slightly subpetaloidal on the dorsal surface (fig. 1 *b*, fig. 3 *b*), and closely biserial on the sides and at the base (fig. 1 *d*, *e*, fig. 1 *c*, fig. 3 *c*); as they approach the peristome, they expand and form five petaloidal expansions around the mouth, which are separated from each other by the five lobes that surround the oral opening (fig. 3 *c*).

The inter-ambulacral areas are largely developed; the antero-lateral are the narrowest, the postero-lateral the widest, and the single area of intermediate width; they are built of large plates bent in the middle, having their surface closely covered with small scrobiculated tubercles arranged in horizontal rows; fig. 1 *f* shows three of these plates and a corresponding portion of the ambulacral area with the poriferous zones, magnified six diameters. The tubercles at the base are larger and wider apart than those on the upper surface, as shown in fig. 3 *g*, where a portion of the base is magnified three diameters; the boss, area, and imperforate tubercle are well seen in this drawing.

The vent opens at the end of a deep sulcus near the middle of the dorsal portion of the single inter-ambulacrum: see figs. 1 *b*, *c*, fig. 3 *b*, *d*; the walls of the sulcus are abruptly perpendicular (fig. 3 *b*, *d*, *e*), and the oval periprocte is seen at the upper portion thereof (fig. 1 *c*, fig. 3 *b*, *d*); the single inter-ambulacrum exceeds in height all the others, for its upper surface is elevated (fig. 1 *a*), and forms the vertex of the test, whilst its under surface is curved downwards and forms a marked prominence in the base (fig. 1 *d*, *e*, fig. 3 *a*, *e*): I have not seen the apical disc well shown in any specimens.

The base is concave, and the mouth-opening occupies a deep depression at the junction of the anterior with the middle third of the base (fig. 3 *c*); the development of the five oral lobes, and the five alternating, petaloidal rosettes impart a remarkable generic character to the only specimen in which this portion of the anatomy of the test is satisfactorily exposed. I have given a figure of this structure, as all the other specimens have the base covered more or less with the coarse grains of the matrix.

Affinities and Differences.—This species resembles *Clypeopygus Cerceleti*, d'Orb., in all the chief points of its anatomy, but differs in the following particulars:—*C. Fittoni* has the test more oblong or subquadrate, and not enlarged posteriorly; the single inter-ambulacrum is more developed, rises higher on the upper surface, and curves lower on the under surface than in d'Orbigny's figure of *C. Cerceleti*.

Locality and Stratigraphical Position.—This rare Urchin was collected from the Lower Greensand of Shanklin, Isle of Wight, by the Rev. T. Wiltshire, F.G.S., and myself. I have dedicated the species to the memory of my old friend Dr. Fitton, F.R.S., whose admirable monograph on the Lower Greensand of the Isle of Wight will long remain a text-book to the explorers of this classical geological region.

Genus—ECHINOBRISSUS, *Breynius*, 1732.

NUCLEOLITES,	*Lamarck*, 1801.
—	*Goldfuss*, 1826.
—	*Agassiz*, 1837.
ECHINOBRISSUS,	*d'Orbigny*, 1855.
—	*Desor*, 1857.
—	*Cotteau*, 1858.
—	*De Loriol*, 1868.

This natural group is composed of small Urchins which have an oval, oblong, subquadrate, or subcircular form, more or less convex on the upper surface, and slightly concave at the base; the test is obtusely rounded anteriorly, more or less produced, truncated, or lobed posteriorly, and in general is narrower at the anterior than the posterior third; the vent opens into an anal sulcus which in one group extends from the apical disc to the posterior border, and in another is limited to the lower third of the inter-ambulacrum; the periprocte was closed by a series of small anal plates usually absent in fossil forms, but preserved in the only living descendant of the genus.

The base is more or less concave; the mouth-opening is small, pentagonal, excentral, and lodged in an excentral depression; in one group the peristome forms a regular pentagon; in another group it is directed obliquely across the test.

D'Orbigny has separated the latter into a distinct genus under the name *Trematopygus*, all of which are special to the Cretaceous Rocks; and they form a convenient section of the genus, although the characters on which the separation is based are, from my point of view, too slight and evanescent to form a stable generic basis. The apical disc is small, quadrate, and compact; it is composed of four perforated and one imperforate genital plate, the right antero-lateral, supports the madreporiform body; the five oculars are very small and triangular, and are wedged in between the genitals and apices of the lanceolate ambulacra.

The tubercles are small, with perforated summits and depressed areas, and the surface of the plates is covered with microscopic granulations.

The genus *Echinobrissus* was established by Breynius in 1732 in his important memoir 'De Echinis et Echinitis,' and of which I have given a translation at p. 193.

Klein, who published only two years afterwards, did not, unfortunately, preserve the well-defined genera proposed on such good characters by his learned contemporary; and Leske, his commentator, in 1778 placed the *Echinobrissus* of Breynius under the *Spatangus* of Klein. When Lamarck in 1801 proposed the genus *Nucleolites* in the first edition of his great work, he was not aware that the same group of Urchins had been well figured and accurately diagnosed sixty-nine years before by Breynius; but in the second edition of 'Animaux sans Vertèbres' a reference was made to this work for figures of the species. The late Professor Agassiz in dismembering Lamarck's *Nucleolites* unfortunately did not restore Breynius' genus, although, as a rule, Agassiz adhered to the genera of the older naturalists. To the late Professor A. d'Orbigny the honour is due of vindicating the claims of Breynius's work, and which all subsequent Echinologists, Desor, Cotteau, and De Loriol, have rigidly observed.

Echinobrissus lacunosus, *Goldfuss*,[1] 1829.

Nucleolites lacunosus,	*Goldfuss*.	Petref. Germaniæ, pl. xliii, fig. 8, p. 141, 1829.
—	—	*Desmoulins*. Études sur les Échinides, p. 360, 1837.
—	—	*Morris*. Cat. of Brit. Foss., p. 55, 1843.
—	—	*Agassis* et *Desor*. Cat. raison., p. 97, 1847.
—	—	*Forbes*. Mem. Geol. Survey, Decade i, p. 8, 1849.
Echinobrissus	—	*d'Orbigny*. Pal. Franç. Ter. Crét., pl. 958, figs. 7—10, 1855.

Diagnosis.—Test ovate, obtuse anteriorly, subquadrate and subtruncate posteriorly, sides subcompressed; upper surface convex, vertex subcentral or supra-anal; ambulacra narrowly lanceolate; anal sulcus deep, short, oblong, and abruptly declined; inter-

[1] No specimen has been found hitherto sufficiently perfect for the purpose of illustration.

ambulacrum subdepressed, recurved; base concave; mouth-opening surrounded by five short petaloid poriferous zones.

Dimensions.—Length seven tenths of an inch; breadth half an inch.

Description.—The test of this species is obtusely rounded before, and subquadrate and truncated behind; the sides are slightly compressed, and the posterior third is the widest part of the ambitus. The upper surface is convex and the under surface concave, and inclined upwards towards the posterior border.

The ambulacral areas are narrowly lanceolate, and the dorsal poriferous zones slightly subpetaloidal on the sides and base; the pores are scarcely visible on the upper surface, but around the mouth they form a five-rayed star of short petaloidal pores, with five oral lobes between them, as in *Clypeopygus*.

The apical disc is small and excentral; four of the ovarial plates are perforated. The surface is covered with scrobiculated tubercles. The mouth is situated at the junction of the anterior with the middle third, and is surrounded with the short rosette of pores already described; the base is concave between the sides, and curves upwards towards the anterior and posterior borders, so that the borders of the postero-lateral inter-ambulacra are convex and prominent at the sides and base, and impart to this Urchin one of its best diagnostic characters. The anal sulcus is short, deep, oblong, and abruptly declined, and occupies the region above the posterior border of the inter-ambulacrum; the vent opens at the extreme end of the sulcus above the middle of the test.

Affinities and Differences.—This Urchin was well figured by Goldfuss, and much resembles *Echinobrissus similis*, d'Orbigny, which appears to be a large variety of *E. lacunosus*. It resembles *E. Roberti*, Gras, from the Upper Neocomian, but is distinguished from that form by the following characters: the anal sulcus is lower, narrower, and nearer the border; the sides are less inflated and more compressed; and the base curves more upwards posteriorly.

Locality and Stratigraphical Position.—This Urchin has been long collected in the Upper Greensand at Longleat, Wilts, and from the Chloritic Marl at Chardstock; the type-specimen was obtained from the Chalk-marl near Essen on the Ruhr, Westphalia.

ECHINOBRISSUS MORRISII, *Forbes*, 1849.

CASSIDULUS LAPIS-CANCRI,	*Morris.*	Cat. Brit. Foss., p. 49, 1843.
NUCLEOLITES MORRISII,	*Forbes.*	Mem. Geol. Surv., decade i, p. 8, 1849.
— —	*Morris.*	Cat. Brit. Foss., 2 ed., p. 84, 1854.
ECHINOBRISSUS —	*d'Orbigny.*	Pal. Franç. Ter. Crétacés, pl. 959, 1854.

Diagnosis.—Test oblong, anterior and posterior borders obtusely rounded; sides

compressed, dorsal surface convex; ambulacra lanceolate, subpetaloidal; apical disc excentral and forwards; vertex central; anal sulcus short, deep, and subtriangular; base concave; mouth-opening pentagonal, slightly excentral, and forwards.

Dimensions.—Antero-posterior diameter half an inch; height three tenths of an inch.

Description.—The test is oval and depressed, obtusely rounded before, a little angular, subrostrated, and sloped out behind, and the greatest diameter is at the posterior third. The upper surface is convex; the longitudinal profile shows it to be rounded and depressed at both extremities, with a slight excentral elevation nearer the anterior than the posterior border. The ambulacra are long, lanceolate, and subpetaloidal on the dorsum, narrower at the ambitus, and enlarged in the base; the poriferous zones have the pores unequal, and a little apart above where they form the petals; they are close together and microscopic at the ambitus, and are larger and more numerous near the mouth, where they form a pentagonal star around the peristome. The anal sulcus occupies the lower fourth of the single inter-ambulacrum; it is short, deep, and triangular, and its two lateral walls form prominent carinæ, the sulcus making an excavation in the posterior border; the vent is oval and opens at the summit of the valley.

The apical disc is small, quadrate, with four perforated genital pores; it is slightly excentral and placed a little forwards, and forms the vertex of the test.

The base is very concave, always near the mouth, and greatly undulated at the sides, the single inter-ambulacrum being slightly subrostrated and recurved.

The mouth-opening is excentral, the peristome pentagonal, with one angle directed forwards, and the pores increase in size and number in the ten zones around this aperture.

The scrobiculated tubercles closely cover all the upper surface; beneath they are larger and not so numerous.

Affinities and Differences.—This species, which is very rare in England, was said by the late Professor A. d'Orbigny to resemble *E. Bourguignati*, but to be distinguished from it by having the test much more depressed, subrostrated behind, compressed at the sides, humped at the vertex, and more concave and undulated on the under surface.

Locality and Stratigraphical Position.—According to the late Professor Forbes, who first separated the species from *E. lacunosus*, and gave only an imperfect diagnosis without any figure of the same, this Urchin is found in the Upper Greensand of Warminster and Blackdown, and the type was detected in Professor Tennant's collection. On the Continent it was collected by the late Vicomte d'Archiac from "l'Étage Cénomanien" at Brunswick. Unfortunately the figure of this species was not drawn by my late lamented friend Mr. Bone, as he was waiting to procure a good specimen to draw, and had not obtained one when it was required.

Genus—Trematopygus, *A. d'Orbigny*, 1855.

Nucleolites (pars), *Agassiz.*
Echinobrissus (pars), *Desor.*
Phyllobrissus (pars), *Cotteau.*
— (pars), *De Loriol.*

Form of the test ovate or oblong, a little contracted and rounded before, and more or less enlarged behind.

Upper surface convex, ambitus inflated, posterior inter-ambulacrum slightly rostrated.

Apical disc quadrate, excentral, and nearer the anterior border, composed of four perforate ovarial and one single imperforate plates; the madreporiform body covers the genital elements and forms a prominence in the centre of the disc; the five ocular plates are very small and closely united to the genitals.

The ambulacra are long, lanceolate, and well defined throughout; the poriferous zones are subpetaloidal on the upper surface; the outer rows of the dorsal pores are elongated transversely at the ambitus and base, they are equal, biserial, and microscopic, and around the peristome a few supplementary pairs are present, which are larger and more conspicuous than the others.

The inter-ambulacra are built of large plates bent in the middle, having their surface covered with two or three irregular rows of tubercles, which are perforated, raised on mammelons, and encircled by depressed areas having circles of granules around them, and the inter-tubercular surface is covered with a fine granulation.

The anal sulcus is large, shallow, and limited to the posterior border; the vent is large, oval, or pyriform, and opens near the surface.

The base is flat or slightly concave towards the middle; the mouth-opening is irregularly pentagonal, compressed obliquely from left to right, and from above downwards.

Trematopygus is only a sectional group of the genus *Echinobrissus*, characterised by an oblique compressed peristome, and by the large elongated vent placed in a marginal shallow sulcus.

TREMATOPYGUS FARINGDONENSIS, *Wright*, 1871. Pl. LVII, fig. 1 *a*—*h*.

TREMATOPYGUS FARINGDONENSIS, *Wright*. In Phillips' Geology of Oxford, p. 434, 1871.

Diagnosis.—Test gibbous, oval, much inflated at the sides and base, narrow in the anterior, and enlarged in the posterior third. Apical disc and vertex excentral and forwards; ambulacra lanceolate, dorsal pores subpetaloid, and sulcus excavated out of the posterior border; vent pyriform, large; base concave, sides undulated by the inflation of the inter-ambulacra; mouth-opening large and oblique, and situated at the junction of the anterior with the middle third.

Dimensions.—*a*. Length one inch and three tenths; height seven tenths of an inch; breadth one inch and two tenths. *b*. Length one inch and five tenths; height seven tenths; breadth one inch and three tenths.

Description.—The test of this rare Urchin has an oval outline, is a little narrower before than behind, and is much inflated at the sides and base. The upper surface is convex with the vertex excentral and forwards, fig. 1 *a* and *b*.

The ambulacra are long, lanceolate, unequal, petaloid; the posterior pair are much longer than the others, and the single area is the shortest and narrowest; at the under surface the ambulacra form depressions, and the inter-ambulacra elevations, so that the base is undulated at the sides and concave in the middle, fig. 1 *c*.

The poriferous zones are well developed at the upper surface and the external rows are slightly elongated, fig. 1 *b*; at the ambitus and base the pores are small and closely biserial, and become larger and more conspicuous around the peristome, fig. 1 *c*.

The apical disc is small and quadrate, fig. 1 *a*, *b*; the four genital plates are perforated, and the anterior pair set closer together than the posterior pair; the madreporiform body occupies the middle of the disc and forms a prominent button there. The ocular plates are very small and closely united to the other discal elements, see fig. 1 *f*, where the disc is shown magnified six diameters.

The periprocte is pyriform or oval, and acuminated at the upper extremity, fig. 1 *a*, *b*, and *e*; it is quite supra-marginal; the anal sulcus makes a deep indentation in the posterior border, fig. 1 *b*, *d*, *e*, and from its sides two carinæ proceed towards the base, fig. 1 *e*.

The tubercles are prominent and perforated, and raised on bosses surrounded by depressed areas, the margins of which are encircled by granules, and all the inter-tubercular surface is covered with a well-developed granulation, fig. 1 *g*; at the base the tubercles are larger and more spaced out, the mammelons are larger, and the granules surrounding the areas more developed, fig. 1 *h*. In fig. 1 *g* an ambulacral area with the

poriferous zones together with a portion of inter-ambulacra is shown, consisting of three plates magnified six diameters; the arrangement of the tubercles is most accurately given, and their relative size and structure well shown in this drawing.

Affinities and Differences.—This species resembles very much *Trematopygus Campicheanus*, d'Orbigny. Our Urchin is larger and more gibbous, and the anal sulcus wider and more developed; the base likewise is more undulated, from the inflation of the basal portions of the inter-ambulacra; and the arrangement of rows of granules above the pores in the poriferous zones, 'Pal. Française,' pl. 950, fig. 6, is absent in *T. Faringdonensis*. In the absence of specimens with which to compare these nearly allied forms, it is impossible to decide whether they are specifically distinct or only varieties of *T. Olfersii*.

Locality and Stratigraphical Position.—I have collected this Urchin only in the Sponge-gravel beds of Lower Greensand at Coxwell, near Faringdon, Berks. The fine specimen, fig. 1 *a*, was obtained from this locality, and presented to me by my old esteemed friend Thomas Davidson, Esq., F.R.S. I am likewise indebted to E. C. Davy, Esq., F.G.S., Wantage, for several specimens more or less perfect to complete my description of the anatomy of the test of this very rare form. It is worthy of note that the group to which I refer the species all come from beds appertaining to the Middle Neocomian, "*Étage Néocomien moyen*," a fact of importance helping to determine the age of the Sponge-gravel beds of Berkshire.

Genus—CARATOMUS, *Agassiz*, 1840.

Small Urchins with an ovoid or circular test rounded before and often rostrated behind; the sides are thick and inflated, the upper surface is convex, and the apical disc excentral and forwards; the base is convex with a slight depression around the mouth-opening, which has neither lobes nor pores.

The vent is infra-marginal and not visible from the upper surface, it is transversely oblong or triangular, and situated in several species in a rostrated development of the single inter-ambulacrum.

The ambulacra are short and subpetaloid, and the zones are formed of simple, equal, non-conjugate pores, disposed in pairs, which are closely approximated at the summit, apart in the middle of the zone, and approximated at the ambitus, Pl. LVII, fig. 2 *b*, *c*; at the base they are feebly indicated by lines which converge around the mouth-opening.

The tubercles, which are large for so small a test, are scrobiculated, those at the base are the largest, and the surface of the plates likewise is covered with minute granulations.

The apical disc is nearly central, with four perforated ovarials and five small oculars, the spongy body extending into the middle of the disc.

The mouth-opening is nearly central, always obliquely elongated.

This genus belongs essentially to the Cretaceous formations. The Upper Greensand, Craie Chloritée, or Étage Cénomanien, has yielded *C. trigonopygus*, *faba*, *rostratus*, and *orbicularis;* of these the first three are found both in the Anglo-Parisian and in the Pyrenean basins, and the last up to the present time only in the Anglo-Parisian basin.

In the White Chalk, or l'Étage Sénonien are four species—*C. avellanus*, *sulcato-radiatus*, *truncatus*, and *peltiformis*, all of which are found in the Anglo-Parisian basin.

The only specimen discovered in England is *C. rostratus*.

Caratomus rostratus, *Agassiz*, 1840, Pl. LVII, fig. 2 *a—e*.

Caratomus rostratus,	*Agassiz*.	Catalogus Syst. Ectyp., p. 7, 1840.
—	—	*Desor*. Monog. des Galerites, p. 38, pl. 5, figs. 1—4, 1842.
—	—	*Morris*. Cat. of Brit. Foss., p. 49, 1843.
—	—	*Agassiz* et *Desor*. Cat. Rais., p. 93, Modèle No. 81, 1847.
—	—	*d'Orbigny*. Prodrom., t. ii, p. 178, Étage 20e, 1847.
—	—	*Forbes*. In *Morris*' Cat. of Brit. Foss., p. 73, 1854.
—	—	*d'Orbigny*. Pal. Française, Ter. Crétacés, pl. 941, p. 367, 1855.

Diagnosis.—Test thick, depressed, round, inclining to oblong, obtusely round before, and prolonged into a rostrum behind; apical disc slightly excentral; base convex, pulvinated, depressed near the mouth, which is small, oblique, and excentral; vent triangular, infra-rostral at the lower third of the height; ambulacra narrow and obscured by large scrobiculated tubercles.

Dimensions.—Antero-posterior diameter four tenths of an inch; breadth three tenths of an inch; height two tenths of an inch.

Description.—This little Urchin was first figured and described by M. Desor in his beautiful Monograph on the Galerites and has since been figured by d'Orbigny in the 'Paléontologie Française.' The shell is thick and depressed, longer than wide, very obtuse anteriorly, and ending in a prolonged rostrum posteriorly, which gives it a pyriform aspect.

The ambulacra are narrow and scarcely visible, being obscured by large scrobiculated tubercles; in order to expose the poriferous zones it is often necessary to treat the test with some dilute acid. I have never been fortunate enough to obtain so good a specimen as the one which my late esteemed friend Mr. Bone procured for his beautiful

drawings of this species, and of which he has given details all magnified six diameters. The ambulacra are narrow and subpetaloid and the pores in the zones are small, equal, and non-conjugate. The surface of the test is covered with scrobiculated tubercles, which are large in proportion to the size of the shell; these with the thickness of the test serve to obscure the details of its structure.

The apical disc, which is likewise the vertex, is placed a little before the centre, and is composed of four perforated genital and five ocular plates, and the spongy body projects towards the middle of the disc.

The large triangular vent is situated at the under side of the projecting rostrum, fig. 2 *c*, *d*, *e*, and is so completely infra-marginal that the aperture cannot be seen from the upper surface. The great development of the intra-ambulacrum which produces the rostrum forms one of the most marked characters of this species, fig. 2 *c*, and serves to distinguish it from the congeners.

The base is convex and pulvinate; it is a little depressed near the middle, where the oblique mouth-opening is situated, fig. 2 *c*; the lines of zone-pores are here visible, and the scrobiculated tubercles are even larger than on the upper surface.

Affinities and Differences.—This species resembles *C. trigonopygus*, but is distinguished from it by its long recurved rostrum, fig. 2 *c*. The shell is likewise more inflated and the base more convex.

Locality and Stratigraphical Position.—This species is found only in the Upper Greensand near Warminster, Wilts. In France it is likewise special to "l'Étage Cénomanien," or the "Craie Chloritée," from whence it has been collected at Havre, Seine-Inférieure, at Fourras, Charente-Inférieure, and at Vaches-Noires, Calvados.

Family 10—Echinolampidæ, *Wright*, 1856.

Test thin, oval, oblong, elevated, or subdiscoidal; ambulacral areas large, petaloidal; poriferous zones wide, pores distant, united by sutures, and extending nearly to the margin.

Mouth-opening small, subcentral; peristome surrounded by five prominent lobes, and always by a well-developed pentaphylloid floscelle.

Vent oval transversely and infra-marginal.

Apical disc very small, excentral, and composed of four perforated genital and one imperforate plate, with five minute oculars wedged into the circumference of the disc.

Plates of the upper surface covered with several rows of numerous small, closely set tubercles encircled by sunken areolas.

A few species are now living in warm seas; the greatest number are extinct, and

found in the Oolitic, Cretaceous, and Tertiary rocks, where they form important leading fossils of the strata which they characterise.

I include the following genera in this Family:

Echinolampas, *Gray.*	Echinanthus, *Breynius.*
Pygurus, *d'Orbigny.*	Conoclypus, *Agassiz.*
Faujasia, *d'Orbigny.*	Pygaulus, *Agassiz.*

Genus—Pygurus, *d'Orbigny*, 1855.

Echinanthites,	*Leske*, 1778.
Clypeaster (pars),	*Lamarck*, 1801.
Echinolampas (pars),	*Agassiz*, 1836.
Pygurus (pars),	*Agassiz*, 1840.
—	*d'Orbigny*, 1855.
—	*Desor*, 1858.
—	*De Loriol*, 1873.

The genus *Pygurus*, as now limited, is composed of large, discoidal, or clypeiform Urchins, in which the test in general is more or less enlarged at the sides, and rostrated posteriorly; its upper surface is usually depressed, and rarely elevated. The ambulacral areas and poriferous zones in the upper surface form petaloidal expansions, which have an elegant figure, being in general contracted at the border, enlarged in the middle, and attenuated at the apex. The anterior single area is narrower than the antero- and postero-lateral areas; the summit is in general central, or slightly excentral, the inclination being always forwards. The base is concave and much undulated, the wide basal interambulacra swell into prominent cushions, and the narrow ambulacra form contracted valleys between them. The mouth-opening is pentagonal, and always excentral; the peristome is surrounded by five prominent lobes, with which five expanded ambulacral petals alternate; in the poriferous zones near the mouth the pores are closely crowded in triple oblique ranks; these perforated petals form an oral rosette or a penta-phylloid floscelle of considerable dimensions (Pl. LVIII, fig. 1 *c*).

The vent is infra-marginal; it is in general oval, and surrounded by a distinct area, which occupies the rostrated portion of the single interambulacrum; the long diameter of the opening in general corresponds with the longitudinal axis of the test, although it is sometimes transverse (Pl. LVIII, fig. 1 *c*).

The apical disc is very small, and occupies the summit; it is composed of two pairs of

narrow, perforated, and a single rudimentary imperforate, ovarial plate; five minute ocular plates, are interposed between the ovarials (Pl. LVIII, fig. 1 *h*).

The small madreporiform body is attached to the surface of the right anterior ovarial, and forms thereon a spongy eminence, which extends over the other discal elements.

The tubercles are very small on the upper surface, and larger at the base; they are surrounded by sunken areolas, and have their summits perforated; the intertubercular space is covered with close-set miliary granules (Pl. LVIII, fig. 1 *g*).

The genus *Pygurus* first appears in the Lower Oolites, and its species are likewise found in the Inferior Oolite, Fuller's Earth, Great Oolite, Cornbrash, Kelloway Rock, Coralline, and Portland Oolite.

In the Cretaceous formations the species *Pygurus rostratus*, *P. Gillieroni*, *P. Buchii*, characterise the Lower Neocomian or Valangian; *Pygurus Montmolini* and *P. Salevensis* are found in the Middle Neocomian; *Pygurus productus* comes from the Urgonian; *Pygurus Ricordeanus* from the Gault; *Pygurus Lampas* from the Upper Greensand or Cenomanian. Of the eight Cretaceous species one is found in the English Upper Greensand, where it is so rare that I know only of two specimens, and one of these is preserved in the British Museum.

PYGURUS LAMPAS, *De la Beche*, 1819, Pl. LVIII, figs. 1*a*—1*h*.

CLYPEASTER OVIFORMIS,	*Lamarck.*	Anim. sans Vertèbres, t. iii, p. 15, 1816.
ECHINOLAMPAS LAMPAS,	*De la Beche.*	Geol. Trans., 2nd ser., p. 112, t. iii, fig. 3, 1819.
PYGURUS TRILOBUS,	*Agassiz.*	Cat. Syst. Ecty., p. 5, 1840.
— —	*Agassiz* and *Desor.*	Cat. rais., p. 103, Modèle No. 39, 1847.
— —	*d'Orbigny.*	Prodrome, t. ii, p. 178, Étage 20, 1847.
— OVIFORMIS,	*d'Orbigny.*	Pal. Française, t. 919, tom. vii, p. 311, 1855.
— LAMPAS,	*Desor.*	Synopsis Echinides foss., p. 311, 1858.

Diagnosis.—Test high, very convex above and concave beneath, much longer than wide, largely rostrated, and abruptly truncated behind; ambulacra lanceolate, poriferous zones subpetaloidal, apical disc and vertex excentral; base very concave and much undulated; mouth excentral; peristome surrounded by a pentapetaloid floscelle of complicated structure; interambulacrum much developed, recurved, and truncated; vent transverse and infra-marginal.

Dimensions.—This very rare British Urchin was first noticed by my old esteemed friend Sir Henry De la Beche, F.R.S., who collected it from the Upper Greensand near Lyme Regis, and figured it in the 'Transactions of the Geological Society,' depositing the specimen

in the British Museum. Sir Henry called it *Lampas*, from its resemblance to an ancient lamp when held with the base uppermost. Lamarck, 1816, described a *Clypeaster* as *C. oviformis*, from the South Sea, collected by Peron and le Sueur, and referred "la variété que se trouve fossile dans les vignes aux environs du Mans" to the same species. From the angular character which the posterior half of the test exhibits Agassiz called it *trilobus*. D'Orbigny, finding that Lamarck had noticed the fossil species from Mans as a variety of *C. oviformis*, has given this name to the fossil, which is quite distinct from the living form. I have, therefore, followed my friend Professor Desor, and retained Sir Henry De la Beche's most appropriate name.

The test is oval or oblong, obtusely rounded before, hollowed out on the sides, and prolonged into an abruptly truncated rostrum behind; it is very convex, and inflated on the upper surface, its profile forming a regular curve, which is a little more depressed behind the vertex than before (fig. 1 *a*). The ambitus is very angular (fig. 1 *a*, *b*) in its posterior half, and the two lateral and one posterior lobe gives value to the name *trilobus* which was proposed for it. The single inter-ambulacrum is much prolonged, and on it two carinæ are developed, which proceed from the apical disc to the sides of the truncated border (fig. 1 *b*, *c*), and impart a still more angular appearance to the test.

The ambulacra are largely petaloid on the upper surface (fig. 1 *b*). They are contracted at the ambitus (fig. 1 *d*, *e*), and are again largely developed and petaloidal at the base (fig. 1 *c*).

The poriferous zones are well developed and visible throughout in the petaloidal portion on the dorsum; the pores in the external row are elongated, and in the internal row round; at the ambitus they are remote and microscopic, and in the base they again become largely petaloidal, where they surround the mouth; the petals here are distinguished by their elegant forms and complicated structure; the pores are increased in number, and set in oblique pairs on the sides of the petals, and in the centre of each is a longitudinal enlargement like the stem of a leaf (fig. 1 *c*). This remarkable structure is shown magnified two diameters.

The large plates on the upper surface have several rows of small tubercles, which become larger and less numerous at the base (fig. 1 *g*); besides these a fine close-set granulation covers the surface of all the plates.

The apical disc is very small, so that the lanceolate ambulacra meet close together at the vertex, which is slightly excentral; there are four perforated genital plates, with a small spongy body in the centre (fig. 1 *h*).

The vent is large, transversely oval, and opens near the border of the infra-marginal portion of the rostrum (fig. 1 *c*).

Affinities and Differences.—This fine Urchin is distinguished from its congeners by its elevated upper surface, angular ambitus, prolonged rostrum and hollowed-out sides, by its rostral carinæ, and the remarkable pentapetaloid arrangement of the pores around the peristome.

Locality and Stratigraphical Position.—It was collected from the Upper Greensand near Lyme Regis, where it appears to be very rare, as I have seen only one other English example in addition to Sir Henry De la Beche's gift to the British Museum. In France it is found not unfrequently in the Micaceous Sandstone, l'étage Cénomanien of Mans, Sarthe, and in the Grès Calcarifère (Cénomanien), of Fouras, Charente-Inférieure.

Family 11.—CLYPEASTERIDÆ, *Wright*, 1856. (Not yet found in British Cretaceous strata.)

Family 12.—SPATANGIDÆ, *d'Orbigny*, 1853.

The general outline of the urchins of this family is oval, oblong, or cordiform, and they satisfactorily exhibit the bilateral symmetry of the Echinidæ. The mouth is anterior, bilabiate, and edentulous. The anal opening is posterior and supramarginal, and closed by a complicated series of small periproctal plates. The ambulacral areas are united at the summit of the test. The anterior single ambulacrum has a different structure from the antero- and postero-lateral pairs, and is lodged in a depression of the test, which extends to the anterior border and forms the anteal sulcus; the test is extremely thin, and covered with small perforated tubercles, which support hair-like spines; besides these there are some larger crenulated and perforated tubercles, which support large spines. There are two or four genital pores, which are sometimes placed close together, but in other genera are apart. The eye-plates are five in number, and placed in a pentagonal form at the apices of the ambulacra around the genital plates. We observe on the surface of the test of some Spatangidæ certain delicate lines called *fascioles*, having a smoother appearance than the tubercular surface of the test; they are furrows which are strewed with microscopic tubercles destined to carry very delicate spines which, when seen under the microscope, appear to have a structure similar to the Pedicellariæ. The fascioles have a different disposition in each genus, and afford a good generic character in giving definitions of the same; when the fasciole surrounds the ambulacral petals like an undulating groove, as in *Hemiaster*, *Schizaster*, &c., it is said to be peripetalous; when it surrounds the single ambulacrum, as in *Amphidetus*, it is internal; when it extends along the sides, as in *Schizaster*, it is lateral; when it encircles the circumference of the test, as in *Pericosmus*, it is marginal; when it is limited to the base of the anal opening it is

subanal. We find sometimes in the same genus more fascioles than one; thus the subanal and peripetal are frequently associated together.

This family contains many genera, none of which are found in rocks older than the Cretaceous formations; the species increase in number in the Tertiary beds, and attain their greatest development in our present seas. In the Cretaceous rocks we find the extinct genera

Hemiaster, *Desor.*	Enallaster, *d'Orbigny.*
Epiaster, *d'Orbigny.*	Heteraster, *d'Orbigny.*
Micraster, *d'Orbigny.*	Echinospatagus, *Breynius.*

The new genus *Paleopneustes*, Al. Agassiz, proposed for a species brought from Barbadoes by the Hassler expedition, appears to furnish an interesting link between the Echinocoridæ and Spatangidæ. In its general form it resembles *Echinocorys vulgaris*, its anteal sulcus is rudimentary, and it has structural affinities with the anterior single area of that Urchin. The other ambulacra are subpetaloidal; and the peristome bilabiate with well-developed lips.

Genus—Hemiaster, *Desor*, 1847.

Urchins with a short, elevated, inflated, or cordiform test. The ambulacral summit in general excentral and posterior. The pairs of ambulacra petaloidal, unequal in length, and lodged in depressions of the surface; poriferous zones large and equal in the same ambulacra, the pores elongated and placed close together. The single ambulacrum lodged in a long, shallow, anteal sulcus; the poriferous zones are very narrow and composed of small round pores, sparsely disposed in oblique, widely separate, simple pairs.

The fasciole single, peripetalous, and circumscribing the ambulacra.

The apical disc small and compact, four perforated genital plates, and five very small oculars.

Peristome bilabiate, very excentral, opening at the anterior fourth part of the base.

Periprocte opening high up on the posterior border, which is in general flat, and obliquely truncated.

Hemiaster differs from *Micraster* in having a single peripetalous fasciole and no anal fasciole; the test likewise is in general shorter, more inflated, and the posterior pair of ambulacra are much shorter than the anterior pair. *Hemiaster* differs from *Periaster* in having only a peripetalous fasciole, the latter having both peripetalous and lateral fascioles.

HEMIASTER MORRISII, *Forbes*, 1854. Pl. LXI, fig. *a*—*k*.

SPATANGUS PRUNELLA,	*Mantell.* Geology of Sussex, pl. xvii, figs. 22, 23, 1822.
HEMIASTER —	*Desor.* (pars) Cat. raisonée, p. 122, 1847.
ECHINOSPATANGUS CORDIFORMIS,	*Mantell* (pars). Geol. Sussex, p. 108, 1822.
SPATANGUS COMPLANATUS,	*Mantell.* Medals, p. 355.
HEMIASTER PUNCTATUS,	*d'Orbigny.* Pal. Franc. Ter. Cret., pl. 886, 1854.
— MORRISII,	*Forbes.* Morris, Cat. Brit. Foss., 2nd ed., p. 81, 1854.
— —	*Woodward.* Mem. Geol. Surv., decade v, pl. ix, 1856.

Diagnosis.—Test oval, polygonal, or cordiform, inflated, obtusely rounded before and obliquely truncated behind, sides nodulated; ambulacra straight, narrow, moderately depressed, anterior pair twice as long as posterior, anteal sulcus short, shallow, dorsal; apical disc excentral backwards; vertex near posterior border, which is flat and obliquely truncated; periprocte oval, supra-marginal; base convex, with a slight depression near the mouth, which is bilabiate and opens near the border; fasciole narrow, distinct, closely surrounding the petals.

Dimensions.—Antero-posterior diameter one inch and six tenths; breadth one inch and five tenths; height one inch.

Description.—This Urchin has been long known to collectors of Cretaceous fossils by many incorrect names. I have now figured it with ample anatomical details for the first time, which for the future will make it impossible to mistake it for any other.

The outline is oval, slightly polygonal, or inclining to a cordate shape; the anteal sulcus is broad and obscure, and impresses slightly the anterior border, which is obtusely rounded and sometimes flattened; the posterior border is obliquely and flatly truncated, and slopes at an angle of 70°; sometimes this border becomes slightly concave in large shells, and it is conspicuously so in three specimens in my collection.

The ambulacral petals are small and moderately depressed, the anterior incline 45°; are nearly twice as long as the posterior pair (fig. 1 *a*); the poriferous zones are narrow, and the pores form oblique transverse slits in them; the single area is about same length as the anterior, and is lodged in the anteal sulcus; there are from twelve to fourteen pairs of pores in each zone, with a prominent granule between each of the pores forming a pair (fig. 1 *a*); the anteal sulcus widens out and disappears at the anterior border.

The inter-ambulacral areas present a remarkable nodulated appearance in this species; in each area there are two rows of these elevations; those at the sides are seen in fig. 1 *a, c;* in the front in fig. 1 *e;* and the back fig. 1 *d;* in fig. 1 *h* the appearance

these nodules present is admirably shown in three inter-ambulacral plates taken from the ambitus and magnified three diameters.

The peripetalous fasciole is very well defined in this species; it passes straight from point to point with scarcely any curvature, and forms a bold line among the numerous tubercles; fig. 1 *g* shows this structure.

The tubercles are small, very numerous, and set irregularly on the plates; they are all perforated, and raised on bosses surrounded by well-defined areolas; fig. 1 *i* shows the tubercles on the upper surface, and fig. 1 *k* those on the under surface, where the larger tubercles have the bosses crenulated; besides the tubercles the entire surface of the plates is closely covered with miliary granules.

The apical disc is small and excentral, the four genital plates are perforated, and the antero-lateral carries the spongy body (fig. 1 *f*); the five ocular plates are very small, as shown in fig. 1 *f*.

The oval periprocte occupies the upper third of the oblique posterior border (fig. 1 *d*), and the vertex is seen rising above it all, as shown in fig. 1 *c*, *d*).

The base is convex transversely behind the mouth (fig. 1 *b*, *c*), and flat before that aperture. The basal portions of the ambulacral areas, especially the postero-lateral pair, which first descend backwards towards the ambitus, bend round the border forming an obtuse angle there, and make a sinuous course to the mouth. The anterior pair and the single area have a more direct course; the basal portions of the postero-laterals are destitute of tubercles and granules (fig. 1 *b*).

The mouth-opening is situated at the anterior fourth of the base; it is transversely arched and bilabiate, the lower lip being the most prominent, and the peristome is surrounded by a narrow calcareous band.

The tubercles on the basal portion of the inter-ambulacrum have a remarkable arrangement. They form a series of curved rows that radiate from a central nodule near the posterior border and from a kind of fan-shaped tubercular sculpture between the two smooth winding paths formed by the sinuous ambulacra (fig. *b*). The tubercles on the other portions of the inter-ambulacra have a much less regular arrangement.

Affinities and Differences.—This species resembles *H. prunella*, Desor, with which it has been confounded; it differs from that species, however, in being much larger, less globular and inflated, having the posterior border obliquely truncated, the dorsum much more inclined, and having the tubercles smaller and more numerous, and the inter-ambulacra nodulated around the sides.

Locality and Stratigraphical Position.—This species is found only in the Grey Chalk near Folkestone, the Lower Chalk at Hamsey, Sussex, and in the Grey Chalk of Ventnor, Isle of Wight.

HEMIASTER BAILYI, *Forbes*. Pl. LX, fig. 2.

ECHINOSPATANGUS, *Mantell*. Geology of Sussex, p. 86, 1822.
HOLASTER ARGILLACEUS, *Morris* (pars.), Catalogue Brit. Foss., 1st ed., p. 54, 1843.
HEMIASTER BAILYI, *Forbes*. Morris, Catalogue, 2nd ed., p. 81, 1854.
— — *Woodward*. Mem. Geol. Surv., decade v, 1856.

The specimen figured in this plate belongs to the Museum of the Royal School of Mines, and is so much crushed and its characters defaced that I am unable to give a correct diagnosis of the species, and now figure it as the authentic example of my late friend's species. The outline figure and general contour of the test resemble *Echinospatagus Murchisonianus*. "The peripetalous fasciole is narrow, distinct, and simple in contour, passing from end to end of the ambulacral petals and only slightly contracted at the sides. The surface of the Echinidæ from the Gault is in general rough with nodular concretions of iron pyrites formed upon the tubercles. So many of the Blackdown fossils are identical with species of the Folkestone Gault that we have felt considerable hesitation in admitting as specific a character which may by any possibility be due to the mineral condition of the specimens."—Woodward.

Locality and Stratigraphical Position.—Collected from the Gault at Folkestone; the type-specimen I have figured is contained in the Museum of the Royal School of Mines.

HEMIASTER ASTERIAS, *Forbes*. Pl. LX, fig. 3.

HEMIASTER ASTERIAS, *Forbes*. In Morris, Catalogue, 2nd ed., p. 81, 1854.
— — *Woodward*, Mem. Geol. Surv., decade v, 1856.

The type-specimen I have figured is not sufficiently well preserved to enable me to form a diagnosis of the species. The vertex appears to have been more prominent and removed more posteriorly than in *H. Bailyi*, and the dorsal ambulacra are likewise rough and narrower in proportion than in that species.

Locality and Stratigraphical Position.—Collected from the Gault at Folkestone, where it is rare. The type-specimen I have figured belongs to the Museum of the Royal School of Mines, Jermyn Street.

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MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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VOLUME FIRST.

PART EIGHTH.

ON THE SPATANGIDÆ AND ECHINOCORIDÆ.

PAGES 265—300; PLATES LXIIA, LXIII—LXIX.

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Genus—Epiaster, *d'Orbigny*, 1853.

Spatangus (pars), Auctorum. Micraster (pars), *Agassiz*.

Form oblong; test more or less elevated, often cordiform.

Antero- and postero-lateral pairs of ambulacra petaloidal and lodged in depressions of the test; the anterior are longer and more developed than the posterior pair. Poriferous zones equal in each ambulacra, composed of elongated pores shorter in the internal than in the external rows.

The single ambulacrum, lodged in a well-defined anteal sulcus, is composed of pores different from those of the antero- and postero-lateral pairs, as they are mostly round and disposed in pairs set widely apart.

The apical disc is composed of four perforated genital and five ocular plates.

Peristome near the anterior border and strongly bilabiate; the inferior lip thick and prominent.

Periprocte round or oval, situated at the posterior border, often opening in a distinct area.

No fascioles.

Tubercles well spaced out, unequal in size, crenulated, and often scrobiculated; intertubercular area covered with granules.

The Epiasters have been long confused with the Micrasters, which they resemble much, but differ from that genus in the absence of all fascioles. They are distinguished from Echinospatagus by their ambulacra, which are in the form of enclosed petals, by their poriferous zones, which are equal, and by their peristome, which is markedly bilabiate.

Epiaster De Loriolii, *Wright*, nov. sp. Pl. LIX, figs. 1, *a*—*g*.

Micraster lacunosus, *Morris*. Catalogue of British Fossils, 1st ed., p. 55, 1843.
Hemiaster bucardium, *Woodward*. Mem. Geol. Surv., decade v, pl. ix, notes, 1856.

Diagnosis.—Test large, cordiform, declining anteriorly, elevated posteriorly; anteal sulcus deep, grooving the border; ambulacra much depressed. Antero-laterals curved slightly forwards and outwards, and inclined at 45°; postero-laterals shorter, curved

backwards and inwards, and inclined at 30°; posterior border obliquely truncated; vent large, oval, supra-marginal; base convex; mouth-opening in the anterior fourth; peristome bilateral.

Dimensions.—Length, antero-posterior diameter two inches and five tenths; breadth, two inches and five tenths; height, one inch and five tenths.

Description.—This fine large *Epiaster* has been long known to geologists as a fossil from the Upper Greensand of Wiltshire, as I have detected specimens in different collections made many years ago. It was erroneously identified with Parkinson's *Spatangus lacunosus*, which is a Maltese specimen, and was entered in the first edition of Morris' Catalogue as *Micraster lacunosus*. It was omitted from the second edition of that work, and described by Dr. S. P. Woodward as *Hemiaster bucardium*, from his belief that it agreed with Goldfuss' figure.

The test is large and cordiform in middle growth, and round and tumid with age, when its width and length are about equal. The vertex is at a point between the terminal portions of the postero-lateral ambulacra, from whence its horizontal profile slopes gently towards the anterior border and backwards to the abruptly truncated posterior border.

The anteal sulcus is deep and narrow, with nearly vertical walls; it grooves deeply the anterior border, fig. 1 *a*, and extends from the disc to the mouth, fig. 1 *e*.

The pores are small, biserial, closely set together, and limited to the upper half of the area, with a prominent granule between the two pores forming a pair.

The ambulacra are much depressed, circumscribed, and unequal in length and inclination; the antero-lateral are one third longer than the postero-lateral pair.

The poriferous zones are wide, of unequal length, and formed of transversely elongated pores, those in the posterior zone of the antero-lateral pair are the longest and there the pores are widest apart.

There is no true peripetalous fasciole, and the naked line which Mr. Bone mistook for this structure and figured as such appears to have been produced by friction on the sutures of the large inter-ambulacral plates forming the peripetalous area added to a certain local baldness at the terminal portions of the depressed ambulacra, so that referring to Plate LIX the student must please delete the peripetalous naked line in fig. 1 *a*, *c*, *d*, *e*, *f*; in all other respects the various figures given on this plate are admirable delineations of the form and structure of this fine *Epiaster*.

The apical disc is central; it has four perforated ovarial plates, a very small spongy body, and five oculars with distinct orbits.

The numerous small tubercles are arranged in rows in quincuncial order on the plates and the interspaces are covered besides with abundant granulations. Fig. 1 *f* represents three inter-ambulacral plates, the terminal portion of an ambulacrum, with its poriferous zones, magnified three diameters in order to illustrate this portion of the anatomy of the test.

Affinities and Differences.—The wide test, deep ambulacra, and inclined upper surface distinguish this Urchin from all its congeners; and likewise from the Micrasters with which others have been often confounded.

I dedicate this fine species to my esteemed friend M. De Loriol, the learned author of the 'Échinologie Helvétique,' whose assiduous studies in Palæontology have borne such ample fruits.

Locality and Stratigraphical Position. This species has been collected from the Upper Greensand, near Warminster and Devizes, Wilts.

EPIASTER GIBBUS, *Lamarck*, 1816. Pl. LXIII, fig. 1, *a*—*k*.

SPATANGUS GIBBUS,	*Lamarck.* Animaux sans Vertèbres, t. iii, p. 32, 1816.
— —	*Deslongchamps.* Enc. Méthod., p. 689, pl. 156, figs. 4—6, 1824.
— —	*Goldfuss.* Petr. Germaniæ, tab. xlviii, fig. 4, p. 155, 1824.
— —	*Defrance.* Dict. Sc. Nat., t. l, p. 94, 1827.
— COR-ANGUINUM,	*Woodward.* Geol. of Norfolk, pl. v, fig. 8, 1833.
— GIBBUS,	*De Blainville.* Manuel d'Actin., pp. 203, 653, 1834.
— —	*Grateloup.* Oursins Foss. (Dax), p. 71, 1836.
— —	*Desmoulins.* Études sur les Échinides, p. 402, 1837.
— —	*Edwards.* Anim. sans Vertèb., t. iii, p. 331, 1840.
MICRASTER CORDATUS,	*Agassiz.* Catal. Syst., p. 129, 1847.
— —	*Hébert.* Études sur les Terr. Crétacés; Mém. Soc. Géol. France, 2e sér., t. v, pl. xxix, fig. 16, 1854.
— GIBBUS,	*Desor.* Synopsis Échid. Foss., p. 365, 1858.
— COR-ANGUINUM,	*Forbes* (pars). Mem. Geol. Surv., dec. iii, pl. x, 1850.
— GIBBUS,	*Forbes.* In Dixon's Geol. of Sussex, p. 342, pl. xxiv, figs. 5, 6, 1850.
— COR-ANGUINUM var. GIBBUS,	*Morris.* Brit. Foss., 2nd ed., p. 83, 1854.
— —	*d'Orbigny* (pars). Paléont. Française Terr. Crét., t. vi, p. 207, 1855.

Diagnosis.—Test cordiform, very high, and almost conical; sides convex and carinated. Ambulacra slightly depressed; anteal sulcus shallow above and grooving the anterior border; posterior margin acuminated and truncated obliquely inwards. Vent

round, supra-marginal; base slightly convex transversely; mouth-opening very near the border, bilabiate, with prominent under lip; apical disc nearly central, and placed before the vertex.

Dimensions.—Height, $1\frac{8}{10}$ inch; length, $2\frac{3}{10}$ inch.

Description.—There has been so much difference of opinion about this Urchin that I have given full details of the anatomy of its test in Pl. LXIII.

Lamarck, who first described it, has the following diagnosis:—"Sp. cordato-abbreviatus, convexus, subgibbosus, antice retusus; vertice elato; ambulacris quinis, duplicato-biporosis; ano ovato;" and refers to the figure in the 'Encyclopédie Méthodique,' pl. 156, figs. 4—6, as the type of the form. Goldfuss gave in his 'Petrefacta' excellent figures and an accurate description. Woodward sketched a fair outline of it in his 'Geology of Norfolk,' but mistook it for the common Chalk species *Micraster cor-anguinum*. Desmoulins, De Blainville, Deshayes, Grateloup, and Desor, all retained the species as established by Lamarck. My late esteemed colleague, Professor E. Forbes, upheld Woodward's mistake, and mentioned it as a variety of *Micraster cor-anguinum* in the 'Memoirs of the Geological Survey,' Decade III, Pl. 10, whilst oddly enough he had previously described it correctly in his account of the Echinodermata in Dixon's 'Geology of Sussex.' D'Orbigny in his 'Paléontologie Française' groups *M. gibbus* with *M. cor-anguinum*, and perpetuates the old confusion I have pointed out.

If we admit that the structure and disposition of a fasciole or *fascioles* form characters of sufficient importance for the establishment of generic groups among the *Spatangidæ*, then, indeed, the Urchin under consideration is not only specifically but generically distinct from *Micraster cor-anguinum*, for, whereas all true Micrasters have a subanal fasciole, forming a ring placed around the base of the posterior border, one half of which embraces the border, the other half the base, the Urchin before us has no fasciole whatever; and this anatomical fact has been altogether overlooked both by Forbes and d'Orbigny, otherwise they would not have confused *gibbus* with *cor-anguinum*.

The build of this Urchin differs from *M. cor-anguinum* in having a flattened base, an angular ambitus, and a pyramidal upper surface, with steeply-inclined sides, the anterior portion sloping at an angle of from 40° to 50°, the posterior from 25° to 30°, and the lateral sides 35°. In half a dozen good typical specimens these measurements represent a fair average. Pl. LXIII, fig. 1, *c*, *d*, *e*.

The ambulacral areas are narrow, and their petaloidal portions not much depressed, fig. 1 *a*, *c*, *d*, *e*; the antero-lateral being one third longer than the postero-lateral pair. The poriferous zones of the petals consist of a pair of holes, the inner being rounder than those in the outer line, and they are connected by a slight depression in the plates, fig. 1 *g*. Beyond the petals the zones diverge; and in the anterior pair I have traced the holes to the ambitus, in the posterior pair they have disappeared. The anteal sulcus is feebly marked, and the single petal shorter than the anterior pair; in the petaloid

section it contains about 20 pairs of holes in each zone, and in the non-petaloidal portion of this area the small pairs of pores can be distinctly traced to the ambitus and onward to the mouth-opening, fig. 1 *e, h.* The ambulacral plates in the petaloidal portions of the areas are elongated and flat in the single area, and short, convex, and tumid in the antero- and postero-lateral pairs. There are several miliary granules on the plates in the single arc and only solitary granules on the convex surface of those in the pairs.

The inter-ambulacral areas are formed of very large plates (fig. 1 *a, c, d, e*), which on the upper surface have a conspicuous mesial suture in each of the areas. All the plates are covered with several horizontal rows of tubercles, arranged in a quincuncial manner, fig. 1 *g*, on their surface, and the inter-areolar space on the same is profusely covered with microscopic granules; fig. 1 *g* exhibits three of the inter-ambulacral and a portion of the petaloid and non-petaloid portions of the ambulacral plates, magnified three diameters; the arrangement of the tubercles and granules is likewise well delineated in this beautiful drawing. The tubercles are raised on bosses encircled by sunken areolas, each of which is surrounded by a circlet of microscopic granules, so that the surface of the test in a well-preserved specimen, such as the type I have figured, is highly ornamented.

The posterior border is a very limited space, and is truncated obliquely downwards and inwards; in its upper portion the vent is situated (fig. 1 *d*). The periprocte is large, circular, and supra-marginal, and its position in relation to the base is very well shown in fig. 1 *c* and fig. 1 *d*.

The apical disc is small in proportion to the size of the shell. It consists of four perforated ovarials and five small, heart-shaped eye-plates; the antero-lateral ovarial is much larger than the others, and extends obliquely into the centre of the disc, with the spongy body covering its surface as in fig. 1 *a*, where the relation of the disc to the petaloid ambulacra is shown, and in fig. 1 *f*, where the disc is drawn magnified eight diameters.

The base is nearly flat, and most accurately delineated in fig. 1 *b*. The course of the basal portions of the postero-lateral ambulacra are observed dividing the base into a central and lateral regions; the central extends from the lower labial prolongation backwards becoming merged in the posterior border, and is closely covered with tubercles, close-set and arranged with great regularity in this space; the lateral regions extending to the sides and anterior border have fewer tubercles, which are larger in size, but more sparse in their distribution than those which occupy the central shield. I have given a figure of the basal tubercles in fig. 1 *k*, showing the boss with its areola and circle of granules, and the perforated tubercle raised on the summit of the radiated bossal elevation. The enlargement is eight times, so that the comparative magnitude of the tubercles on the upper and under surfaces of the test of this species may be fairly estimated by comparing fig. 1 *i* with 1 *k*, and the whole in relation to the test in figs. 1 *a* and *b*.

The mouth-opening is found very near the anterior border, figs. 1 *b*, *c*, and *e*. It is largely and transversely oblong, and the lower lip is thick and much prolonged.

Affinities and Differences.—This Urchin resembles some forms of *Micraster coranguinum*, and has long been considered by many a variety of that common Chalk species. An attentive study of the anatomy of their tests will soon disclose their affinities and differences, which have already been pointed out in the introductory part of the description, and to which I refer the reader.

Locality and Stratigraphical Position.—The most typical examples of this species are found in the Upper Chalk at Harford Bridge, near Norwich, and from the Upper Chalk of Sussex, where it is very rare. The large specimen figured in 'Dixon's Geology of Sussex' is a broad and abnormal form of the species, and is the type of my late colleague's description in the text of that work.

Since this article was in type my friend Mons. de Loriol has called my attention to and given me a copy of a memoir by Dr. Clemens Schlütter ('Verh. d. Nat. Ver. Jahrg.,' xxvi, Folge 3, Bd. vi), "Fossilen Echinodermen des nördlichen Deutschlands," in which the author has published good figures and an accurate description of *Epiaster gibbus*.

Genus—MICRASTER, *Agassiz*, 1836.

SPATANGUS, pars, *Auctorum.*
MICRASTER, pars, *Agassiz.*
MICRASTER, *d'Orbigny.*
MICRASTER, *De Loriol.*

Body oval, oblong, more or less inflated; test cordiform, thin, and fragile.

Ambulacral pairs petaloidal, closed at their extremities, the anterior exceeding in length the posterior pair.

Poriferous zones equal in each ambulacra.

Holes oval or oblong, conjugated by transverse depressions.

Anterior or single ambulacrum lodged in a wide, shallow, anteal sulcus, which deeply indents the border of the test.

Pores small and round, and set obliquely in uniform pairs more or less widely apart, the distance of one pair from another increasing from the disc to the mouth.

Apical disc small, central, solid, composed of four perforated ovarial and five perforated ocular plates.

Madreporiform body small, located in the middle of the disc.

Mouth-opening transverse near the border; peristome bilabiate, with a prominent projecting under lip. Base flat or slightly convex, covered with large, regularly arranged, well-developed tubercles.

Posterior border narrow, obliquely truncated downwards and inwards, and slightly concave transversely.

Vent located in the upper part of the border under a ridge-like projection of the dorsal surface.

Periprocte oval and widely patent.

Fasciole sub-anal, forming a ring around the posterior extremity ; embracing half of the upper and half of the lower part of the border.

Tubercles perforated sparsely, distributed on the upper surface; larger and placed closer together below. All are raised on bosses with crenulated summits.

Spines small, needle-shaped, straight or bent, and enlarged and crenulated at the base.

Micraster differs from *Epiaster* in possessing a well-defined sub-anal fasciole, and from *Hemiaster* and *Periaster* by the absence of a peripetalous fasciole.

Micraster forms a leading genus of fossil Urchins, and well characterises the upper beds of the Cretaceous formation in the Anglo-Parisian, Pyrenean, and Mediterranean basins of Europe.

MICRASTER COR-ANGUINUM, *Klein*, sp., 1734. Pl. LXII, figs. 1 *a*—*l*, 3, 5 (not fig. 4).

BRONTIA vel OMBRIA,	*Plot.* Nat. Hist. Oxfordshire, p. 91, pl. ii, fig. 11, 1677.
ECHINITES PRÆTER RADIOS,	*Lister.* De Lapidibus Turbinatis, p. 224, fig. 28, t. vii, 1678.
ECHINITES CORDATUS VULGARIS,	*Llhwyd.* Lithophylac. Britannici Iconograph, p. 47, Num. 964—967, fig. 964, 1699.
ECHINOSPATAGUS CORDIFORMIS,	*Breynius.* Schediasma de Echinis, p. 62, t. v, figs. 5, 6, 1732.
SPATANGUS COR-ANGUINUM,	*Klein.* Naturalis Dispositio Echinodermatum, p. 28, t. xxiii, figs. A—D, 1734.
— —	*Klein.* Ordre Nat. des Oursins de Mer; ed. Gall., p. 100, pl. xii, figs. E, F, pl. xiii, fig. C, 1754.
— —	*Leske.* Addit. ad Kleinii Disposit. Echinid., p. 221. pl. xxiii, figs. A—D, pl. xxiii* C, and pl. xlv, fig. 12, 1778.
ECHINUS COR-ANGUINUM,	*Gmelin.* Systema Naturæ, p. 3195, No. 91, 1799.
SPATANGUS COR-MARINUM,	*Parkinson.* Organic Remains, vol. iii, p. 28, pl. iii, fig. 11, 1811.
— COR-ANGUINUM,	*Lamarck.* Anim. sans Vert., t. iii, p. 32, 1816.
— PUNCTATUS,	*Lamarck.* Ibid.
— COR-ANGUINUM,	*Deslongchamps.* Encyl. Méthod., t. ii, p. 63, 1824.
— PUNCTATUS,	*Deslongchamps.* Ibid.
— COR-ANGUINUM,	*Defrance.* Dict. Sc. Nat., p. 93, t. l, 1827.
— PUNCTATUS,	*Defrance.* Ibid.

SPATANGUS COR-ANGUINUM,		*Goldfuss.* Petrefacta Germaniæ, vol. i, p. 157, pl. xlviii, fig. 6, 1829.
—	—	*De Blainville.* Dict. Sc. Nat., t. xl, p. 135, 1830.
—	PUNCTATUS,	*De Blainville.* Ibid.
—	COR-ANGUINUM,	*Agassiz.* Prodrom., Mém. Sc. Nat. Neuchatel, t. i, p. 184, 1835.
—	—	*Desmoulins.* Études sur les Échinides, p. 402, 1837.
—	PUNCTATUS,	*Desmoulins.* Ibid.
—	COR-ANGUINUM,	*Agassiz.* Catal. Syst. Ectyp. foss., p. 2, 1840.
—	PUNCTATUS,	*Dujardin.* In Lamk. Anim. sans Vert., 2nd ed., t. iii, p. 328, 1840.
—	COR-ANGUINUM,	*Dujardin.* Ibid.
MICRASTER COR-ANGUINUM,		*Geinitz.* Charakteristik. Petref. Sächs-bohm. Kreidegebirges, p. 91,1842.
	—	*Morris.* Catalogue of British Fossils, p. 54, 1843.
—	—	*Agassiz et Desor.* Catal. rais. des Ech., Ann. Sc. Nat., 3e sér., t. vii, p. 23, 1847.
—	—	*d'Orbigny.* Prodrome Pal. Strat., t. ii, p. 269, 1850.
—	—	*Sorignet.* Oursins foss. de l'Eure, p. 59, 1850.
—	—	*Forbes.* Mem. Geol. Surv., decade iii, pl. x, 1850.
—	—	*Bronn.* Lethæa geognost., Kreidegebirge, p. 200, 1852.
—	—	*d'Orbigny.* Paléontologie Française, Terr. crétacé, t. vi, p. 207, pl. 867 (pars), 1852.
—	—	*Forbes.* Morris, Catal. Brit. Fossils, 2nd ed., p. 83, 1854.
—	—	*Hébert.* Tabl. Foss. de la Craie de Meudon, Mém. Soc. Géol. de France, 2e série, t. v, pl. xxix, fig. 15, 1854.
—	—	*Desor.* Synopsis des Échinides fossiles, p. 364, 1858.
—	—	*Cotteau.* Échinides de la Sarthe, pl. lv, figs. 5—10, p. 326, 1860.

Diagnosis.—Test cordiform, length and width nearly equal. Upper surface more or less inflated in different specimens; enlarged and sinuous before, contracted and tapering behind; the greatest diameter at the anterior third. Upper surface convex; the anterior half declining obliquely from the disc to the anteal sulcus, and the posterior half forming a curved carinal ridge from the disc to the anal area; posterior border flat, scooped out, and inclined inwards; vent above opening under the rostrated carina. Under surface convex; anteal sulcus equally hollowed throughout, from the disc to the mouth; petaloid ambulacra unequal in length and slightly depressed; mouth-opening near the border, with a very stout under lip.

Dimensions.—Height, $1\frac{1}{2}$ inch; length, $2\frac{2}{10}$ inches; width, $2\frac{2}{10}$ inches.

Description.—This common Chalk Urchin has been long known to naturalists, and its flint moulds, collected from the Chiltern downs, were first figured by Plot in his 'History of Oxfordshire,' then by Lister and Llhwyd, and its test by Breynius, Klein, Van Phelsum,

Leske and others. It presents a great many forms which have been considered distinct species by some, but only as varieties by others. The specimen I have selected for figuring and description is a capital type of the species in the highest state of preservation, and the anatomy of the test has been carefully displayed in a series of figures in my late lamented friend Mr. C. R. Bone's best manner.

The test is cordiform, and its width and length are nearly equal; it is enlarged before and contracted behind, and its greatest transverse diameter is at the junction of the anterior with the middle third; the upper surface is inflated; from the disc to the anterior border it is obliquely depressed, fig. 1 *c*, and from the disc to the posterior border it describes a curved line which forms the summit of a carinal ridge extending to the vent and forming a rostrated process at the upper border of the periprocte; the sides are much inflated, fig. 1 *a*, and the posterior border is flat, obliquely truncated downwards and inwards, and with the rostrated carina forms an excavation which imparts a specific character to the species, which is well delineated in fig. 1 *c*.

The pairs of petaloid ambulacra are of unequal length, the anterior pair being the largest; they are not much depressed and very slightly flexed; the poriferous zones are narrow, not rounded at their extremity, and present certain characters which prevail throughout the various forms this species exhibits.

The ambulacral plates are invariably tumid, rugose, and separated by a strongly marked suture, fig. 1 *h*, magnified four diameters; whilst the general suture running down the centre of the ambulacral area is deeply depressed and grooved like fig. 1 *a*; the ridge separating each poriferous groove is also tumid and studded with a single row of five or six small close-set tubercles, fig. 1 *h*.

The single anterior ambulacrum is feebly petaloid in its upper part; its pores are set much closer together than those in the pairs, and in many specimens the grooves connecting the pores are obsolete; the pores of the inner row in the lateral ambulacra is rounder than those of the outer row, which are slightly elongated, fig. 1 *h*; the non-petaloid portion of this area is more fully developed than in the corresponding portion of the others; fig. 1 *i* shows the anterior ambulacrum. It is lanceolate, the plates are wide and irregular, each having a pair of small holes with tubercles placed between them.

The inter-ambulacral areas are formed of large plates eight to ten in each column according to the age of specimen. They attain a greater development at the base, the postero-lateral pair forming the largest portion of the region, fig. 1 *b*; the antero-lateral pair forming the anterior border, fig. 1 *a*, *e*; the carinal ridge, the anal area, the central shield of the base, with its circular subanal fasciole, and highly ornamented tubercular surface, are all formed by the single posterior area, fig. 1 *b*, *c*, *d*.

The surface of the inter-ambulacral plates is covered with highly developed tubercles on the sides and upper surface; each plate has four or five horizontal rows of them more or less regularly arranged as shown in fig. 1 *f*, where two of these plates are drawn magnified four diameters.

The plates in the ambulacral areas likewise support tubercles, but they are smaller and more sparsely distributed than in the inter-ambulacra; the relative magnitudes of the tubercles in the two areas is shown in fig. 1 *f*, where they are both drawn to a scale of four diameters. The tubercles on the sides and upper surface consist of a perforated tubercle, placed upon a crenulated boss, and surrounded by a smooth areolar space, not scrobiculated on the upper surface, but very distinctly so at the base. They become much more numerous around the ambitus, and increase in size on the basal plates of the postero-lateral inter-ambulacral areas, fig. 1 *b*. On the triangular central space extending from the fasciole to the under lip, the tubercles are arranged in well-formed rows that radiate forwards and outwards from a central tubercle and fill the entire space with close-set, regularly arranged tubercles, as shown in fig. 1 *b*; the structure of the tubercles is very well delineated in the enlarged drawing of the same, made from a portion of the base where each areolar space is seen to be surrounded by a circle of granules and the intermediate portion filled in with the same.

The tubercles supported small, needle-shaped spines, some of which are preserved on one of our specimens; of these spines a few are slightly bent near the base, fig. 5; all are marked by fine longitudinal ridges, fig. 3 (destitute of spiral ornaments), which disappear towards the apex; at the acetabulum a crenulated ring is visible. The minute spines with distinct ridges, which extend from base to apex, and which are traversed by a series of spiral depressions, fig. 4, occasionally found in the beds containing *M. cor-anguinum*, belong to *Echinothuria floris* and not to *M. cor-anguinum*.

The apical disc is small and excentral, and composed of four perforated ovarial plates, the right antero-lateral being much the largest and extending into the middle of the disc; it is covered with the madreporiform body. The five ocular plates are wedged into the angular spaces left by the ovarials; the discal elements being firmly soldered together, this portion of the test is nearly always well preserved.

The posterior border is flat, abruptly truncated, and obliquely inclined downwards and forwards. The vent occupies the upper part of this region, and opens immediately under the rostrated carina. A few small tubercles are sparsely disposed below the vent and the lower part of the space is smooth, the fasciole encircles the angle, one half passing above, the other half below the basal angle. It is well seen in most specimens, and I have given a drawing of it in fig. 1 *k*, where it is seen passing as a finely granulated band between the tubercles on the plates.

The mouth is placed very near the border, at the inferior termination of the deeply impressed anterior ambulacrum. It varies in position slightly in different specimens. The lower lip is thick and strong, and varies in the amount of projection, fig. 1 *b* and *e*.

Affinities and Differences.—This species, so long known and so often described, has nevertheless been the subject of much confusion. The older authors, as Lister and Llhwyd, appear to have been acquainted with its moulds in flint. Breynius and Klein studied its test, and the latter described it in 1734 under the name *Spatangus cor-anguinum*.

His figures are very poor, and the varieties which he has united under the name appear to comprise forms which do not properly belong to the type. Goldfuss was the first who, in 1829, gave an exact representation of the test from the able and accurate crayon of Herr Höhe. He separated it from his *Spatangus cor-testudinarium*, with which it had been united; but the authors who followed Goldfuss have forgotten the distinction pointed out by him; thus Agassiz and Desor in 1847 reunited these two species, and considered *Micraster cor-testudinarium* only as a large variety of *Micraster cor-anguinum*. Forbes in 1850, and d'Orbigny in 1853, increased the confusion, for by them nearly all the species of the White Chalk were referred to one and the same type, and *Micraster gibbus*, *rostratus*, *cordatus*, *cor-testudinarium*, *latus*, *armatus*, *brevis*, &c., successively established by different authors, were only admitted as simple varieties of *Micraster cor-anguinum*.

Professor Hébert after a careful study and comparison of the species of Micraster reunited by Forbes and d'Orbigny, arrived at an opposite determination; not only did he admit the validity of *Micraster cor-testudinarium*, *gibbus*, and *brevis*, but he determined two other species. The structure of the ambulacral plates is the principal character upon which M. Hébert founds the description of his species.

In his 'Synopsis des Échinides Fossiles,' published since Professor Hébert's memoir,[1] M. Desor persists in uniting *Micraster cor-testudinarium* to *M. cor-anguinum*, and admits under reserve *M. Brongniarti*, Héb., and *M. Desori*, Héb., proposed therein with such diverse opinions about the true characters of this old fossil. When M. Cotteau was about to describe the species in his classical work on the 'Échinides du département de la Sarthe,' he determined to study the species anew, and for this purpose collected all the necessary documents for reference and numerous specimens for comparison, and says, "Without adopting entirely the conclusions of M. Hébert we believe, nevertheless, that there exists among the Micrasters which d'Orbigny has confounded under the same denomination four species very distinct, viz."

"1st. The *Micraster cor-testudinarium*, Goldfuss," admirably figured and described by Cotteau.

"2nd. *Micraster gibbus*, Agass. *Spatangus gibbus*, Lam." (*Epiaster gibbus* of this work.) "Well represented in the 'Atlas de l'Encyclopédie Méthodique,' pl. clvi, figs. 4—6, and remarkable for its elevated conical form, its long straight ambulacra, its large, flat under surfaces, truncated posterior border, with its vent placed low down near the angle." Remarkable also, I may add, for the want of the subanal fasciole, which has been overlooked by Forbes, d'Orbigny, and Cotteau: so that assuming the presence, absence, or character or number of the fascioles to afford characters for generic division, this species would not belong to the Micrasters at all.

"3rd. The *Micraster Brongniarti*, Hébert, figured for the first time by Brongniart in his 'Fossils from the Environs of Paris' under the name *Micraster cor-anguinum*, and

[1] 'Etude sur les Terr. crétacés, Mém. Soc. Géol. de France,' 2e série, tom. v, pl. xxix, fig. 19.

perfectly characterised by its sub-undulated ambitus, subconvex upper surface, its central ambulacral summit, ambitus much grooved by the single ambulacrum, and its narrow ambulacra deeply depressed. The *Micraster Brongniarti* appears to be special to the Chalk at Meudon, as but one mould has been collected near Sens."

"4th. The *Micraster cor-anguinum*, easily recognised by its cordiform outline, dilated before, acuminated behind, by its elevated and inflated upper surface, convex and rostrated in the posterior region, with narrow and shallow petaloid ambulacra; its ambulacral plates shorter and deeper than in its congeners, and by its excentral apical disc placed in the direction of the posterior border."

Locality and Stratigraphical position.—It is found in all the Upper Chalk districts of England, and is common in Kent, Sussex, and Norfolk. It was recorded by General Portlock from the Chalk of Magilligan, County Derry, Ireland.

Foreign Distribution.—This Urchin is one of the most characteristic of the Upper White Chalk, equivalent of the '22e Étage Sénonien,' d'Orbigny. According to that author it has been collected in the *Anglo-Parisian basin* at Meudon (Seine-et-Oise); Beauvais (Oise); in the Somme; in the Ardennes at Retheil; in the Seine-Inférieure, at Ciqueport, Étretat, Fécamp, Dieppe, Tréport; in the Yonne at Sens, Seigneley, Joigny, Villeneuve-sur-Yonne; in the Eure, at Châteaudun; in the Sarthe, at Saint-Frambault, Roches, Vendôme; in the Loir-et-Cher, at Couture, Villiers, Blois; in l'Indre-et-Loire, near Tours.

In the Pyrenean basin at Périgueux (Dordogne), at Moutiers, Cognac (Charente); at Mirambeau, Coze, Meschers, Saintes (Charente-Inférieure); at Tercis, Rivière, near Dax (Landes); at Mauléon, Magnoac (Hautes-Pyrénées); at Bidart (Basses-Pyrénées). *In the Mediterranean basin* at Soulage, Songraigne (Ande); at Ayglun, Mers, Beausset (Var); and in Scandinavia, Germany, Switzerland, and Belgium in the same geological horizon.

MICRASTER COR-BOVIS, *Forbes*, 1850. Pl. LXII A, figs. 1, 2 *a—d.*

MICRASTER COR-BOVIS, *Forbes*. In Dixon's Geol. of Sussex, pl. xxiv, figs. 3, 4, p. 342, 1850.
— — *Forbes*. Mem. Geol. Surv., decade iii, note, pl. x, 1850.
— — *Forbes*. In Morris' Cat. of Brit. Foss., 2 ed., p. 83, 1854.
— — *Desor*. Synopsis des Échinides Foss., p. 367, 1858.

Diagnosis.—Test large, ovate, slightly cordate, broadest in the region of the antero-lateral ambulacra. Posterior border obtusely subtruncated. Dorsal surface depressed. and slightly elevated in the anterior region above the rest of its surface. Apical disc excentral, nearer the anterior border. Anteal sulcus shallow, petaloid ambulacra short, unequal in length, and slightly depressed. Base convex, vent in the middle of the obtusely sub-truncated border.

Dimensions.—Length three inches; breadth two inches and seven twelfths; height one inch and nine twelfths of an inch.

Description.—My late esteemed colleague in this work, Professor Edward Forbes, gave the following note upon this Urchin in Decade III of the 'Memoirs of the Geological Survey,' in his note on allied species of British species of Micrasters :—"I have given an account of it in Dixon's work on the 'Geology of Sussex,' where it is excellently figured. I have there named it *Micraster cor-bovis*. It is usually a larger and longer species than *cor-anguinum*, and its petaloidal ambulacra are more deeply impressed and much shorter in proportion to the body. The shape is ovato-cordate, the curve of the sides from the front of the antero-lateral ambulacra to the anal extremity being but slight, its chief swelling being near the anus, and not on a line with the postero-lateral ambulacra as in *cor-anguinum*. The back is more equally depressed than in the depressed variety of the last-named species. The mouth is much smaller comparatively, and the post-oral spinous space, though much longer, in consequence of the elongation of the hinder portion of the test, is nevertheless proportionally broader. The tubercles of the plates, whether dorsal or ventral, are much smaller and more scattered. Besides all these comparative characters, there is the positive one that in *cor-bovis* the ambulacral plates, instead of being tumid, are smooth and plain, as are also the ridges separating the sulcations of the pairs of pores in the petaloidal ambulacra. The ambulacral spaces are wider than the breadth of any of the sulcations."

It will be more satisfactory if I here insert Forbes' note from the work referred to:

"The body of this fine and large *Micraster* is ovate and slightly cordate, broadest in the region of the antero-lateral ambulacra. The posterior end is obtusely subtruncated. The dorsal surface is depressed and but slightly elevated in the anterior region above the rest of its surface.

"The ovarian circle is placed nearer the anterior than the posterior end. The frontal groove is shallow. The lateral ambulacra are placed in gentle depressions.

"The postero-lateral ambulacra are very short, and little more than half the length of the antero-laterals. There are about thirty pair of pores in each row in the latter and about seventeen in each row in the former. The larger tubercles of the dorsal plates are much scattered and minute in proportion to the size of the shell. The interstices are minutely granulated.

"The areolated tubercles of the ventral surface are also proportionally small. The post-oral spinous space is triangularly lanceolate."

Affinities and Differences.—This species resembles *M. breviporus*, of which it has long appeared to me to be a gigantic variety.

Locality and Stratigraphical Position.—Dixon's type was collected from the White Chalk, Sussex, others are found at Charing, Kent, and some fine specimens in the Woodwardian Museum, Cambridge, were obtained from Balsham, near Cambridge; it occurs low down in the White Chalk.

MICRASTER BREVIPORUS, *Agassiz*, 1840. Pl. LXII A, fig. 3 *a—b*.

MICRASTER BREVIPORUS,		*Agassiz.* Cat. Ectyp. Foss. Mus. Neo., p. 2, 1840.
—	—	*Agassiz et Desor.* Cat. raisonné des Échinides, p. 130, 1847.
—	—	*d'Orbigny.* Prodrome, t. ii, p. 270, 1850.
—	—	*Sorignet.* Oursins de l'Eure, p. 62, 1850.
—	LESKEI	*d'Orbigny.* Paléont. Française Ter. Crétacés, tom. vi, p. 215, pl. 869, 1853.
—		*Desor.* Synopsis des Échinides Foss., p. 366, 1858.
—	—	*Coquand.* Synopsis des Foss. des Charentes, p. 134, 1860.
—	—	*Cotteau.* Cat. des Échinid. de l'Aube, p. 34, 1865.
MICRASTER BREVIPORUS,		*Hébert.* Comp. rend. de l'Institut. 25 Juin, 1866.
—	—	*Schlönbach.* Beiträg. des Grünsandes von Rothenfelde, p. 14, 1869.
—	—	*De Loriol.* Echin. Helv. Échinides Crétacées de la Suisse, 2me partie, p. 369, pl. xxxi, fig. 5, 1873.

Diagnosis.—Test largely cordiform, rounded and grooved before, contracted behind and truncated at the posterior border. Upper surface uniformly convex, declining a little more anteriorly than posteriorly, with a prominent carina between the apical disc and posterior border; base convex, ambitus slightly undulated, rounded, and inflated.

Dimensions.—Antero-posterior diameter $1\frac{9}{20}$ inch; transverse diameter $1\frac{4}{10}$ inch; height $1\frac{1}{4}$ inch.

Description.—The test of this Urchin has a cordiform shape; it is rounded and slightly grooved anteriorly, and tapers gently to the posterior border, which is truncated downwards and a little inwards. The upper surface is depressed and uniformly convex, and declines a little more to the anterior than the posterior border; a prominent carina more or less elevated in different individuals extends backwards from the apical disc to the summit of the periprocte, and divides into two ridges, which descend on each side of the vent towards the lower part of the posterior border, where they disappear near the fasciole.

The ambulacra are short and straight, very unequal in length, and slightly depressed. The anterior single ambulacrum is lodged in a sulcus, which grooves the anterior border and extends to the peristome; its pairs of pores lie wide apart, and are nearly obsolete. The anterior pair are large and divergent; they occupy well-marked depressions, and their poriferous zones consist, in one of my specimens, of 30 pairs of holes, each having a connecting groove between the holes. The posterior pair are slightly bent and directed backwards, and are about two thirds the length of the anterior pair. The pores are similar in structure, and there are 18 to 20 pairs in each zone. The ambulacral plates are concave, smooth, and plain, those of the single area alone carrying miliary granules.

This structure of the ambulacra forms a good diagnostic character between this species and *M. cor-anguinum*.

The apical disc is very small, and lodged in a valley formed by the confluence of the apices of the five ambulacra; the madreporiform tubercle occupies the centre, surrounded by four ovarial holes, the posterior pair being wider apart than the anterior pair; the culminating summit of the upper surface being immediately behind the disc.

The periprocte is situated at the upper part of the obliquely truncated posterior border, and its position is persistently the same in all the six specimens before me.

The base is flattened, the portion between the peristome and anterior border is slightly hollowed out. The plastron is wide and filled with large close-set tubercles, these radiate in regular rows from a point rising near the middle of the fasciolar line; the lateral portions slope away to the ambitus; the valleys between indicate the course of the basal portions of ambulacra between the border and the mouth, which is situated at a short distance from the anterior sulcus, and is bilabiate, and surrounded by a rosette of pores and tubercles very regularly arranged in the small specimen figured in 3 *b*.

Affinities and Differences.—*Micraster breviporus*, which has long been considered to be a variety of *M. cor-anguinum* and of *M. cor-testudinarium*, is distinguished from them by its outline, which is more elongated and depressed, tapering at the sides, and less acuminated posteriorly; its upper surface is more uniformly convex, its ambulacral summit is excentral and placed forwards, and its petaloidal ambulacra are shorter and less depressed, and the ambulacral plates are smooth and not tumid as in *M. cor-anguinum*.

Micraster laxoporus, d'Orb., has the summit more central, the ambulacra much more depressed, the anterior half of the upper surface more declined, and the posterior half more strongly carinated. I have compared my specimens from Brighton and Norfolk with a type-specimen kindly given me by my excellent friend M. De Loriol, which was collected at St. Julien du Sault (Yonne); from the "étage Sénonien," equal to our White Chalk. M. De Loriol[1] says, "In 1837 M. Desmoulins gave the name of *Spatangus Leskei* to the Urchin figured by Klein under the name *Spatangus cor-anguinum*, var. *Norvagicum* and var. *productum*, which differs really from the true *Spatangus cor-anguinum*. D'Orbigny and other authors have referred to this *Micraster* (*Spatangus Leskei*) the species named by the late Professor Agassiz *Micraster breviporus*. Recently M. Hébert having been able in Denmark to examine the original specimens of the species which Klein had figured under the name *Sp. cor-anguinum*, var. *Norvagicum*, has recognised that it differs in reality from *Micr. breviporus*, and that it ought to be separated, and continue to bear the name *Micr. Leskei*, which appears to be a form special to the Upper Chalk of the north of Europe.

Locality and Stratigraphical Position.—My specimens of this species have been collected from the Upper Chalk of Brighton, Sussex; Balsham, Cambridge; and from the

[1] 'Paléontologie Suisse Échinides Cretacés,' p. 370.

Upper Chalk near Norwich, out of the same terrain that yielded *Cardiaster granulosus*, *Card. excentricus*, and *Epiaster gibbus*.

In France it has been collected from the White Chalk at Fécamp, Étretat, and Dieppe, the environs of Beauvais, Méru (Oise); of Vervins and La Capelle (Aisne); of Andelys, Caussols (Var); of St. Julien du Sault (Yonne).

In Switzerland (according to De Loriol) from the Seewerkalk of Sentis (Appenzell); the Grands Troncs near Semsales (Fribourg), Étage Sénonien.

Genus—ECHINOSPATAGUS, *Breynius*, 1732.

ECHINOSPATAGUS (pars), *Breynius*, 1732.
SPATANGUS (pars), *Klein*, 1734.
SPATANGUS (pars), *Lamarck*, 1816.
TOXASTER (pars), *Agassiz*, 1840.

Body cordiform, more or less inflated at the upper surface, and in general flattened at the base.

The pairs of ambulacra petaloidal, unequal in length, always large, and lodged in depressions of the test; poriferous zones wide and slightly unequal in the anterior pair; pores in the form of narrow slits, those of the outer being longer than those of inner rows; the anterior poriferous zones are longer than the posterior. The single ambulacrum is lodged in a wide, deep, anteal sulcus, its poriferous zones are narrow and equal with each other, and the holes are smaller and placed closer together than the pores in the pairs.

The apical disc is compact and solid, composed of four perforated ovarial plates and five small oculars, minutely and finely perforated; the madreporiform body extends into the centre of the disc.

The mouth-opening is situated near the anterior border, and the peristome is small and subpentagonal.

The vent is situated in the upper part of the posterior border, and the periprocte is oval.

The tubercles, of various sizes, crenulated and scrobiculated, are placed in two or three irregular rows on the plates; they are most numerous at the anterior border and around the ambitus, and are sparsely scattered on the base; the surface of the plates is likewise covered with a very fine close-set miliary granulation.

The absence of fascioles from all parts of the test distinguishes this genus from *Hemiaster*, with which it has been often confused. The type-species so common in the Neocomian strata of France and Switzerland was first figured by Breynius as *Echinospatagus cordiformis*.

It was afterwards figured and described by Agassiz as *Holaster complanatus*, and subsequently separated from that group to form the type of his genus *Toxaster*. As this corresponds with the *Echinospatagus* of Breynius, the laws of priority demand the restitution of the original name, however much we may regret these changes of nomenclature.

ECHINOSPATAGUS MURCHISONIANUS, *Mantell*, 1835. Pl. LX, figs. 1, *a*—*i*, and Pl. LXIV, fig. 1.

SPATANGUS MURCHISONIANUS, *Mantel.* Geol. Trans., 2 ser., vol. iii, p. 210, 1835.
— — *Desmoulins.* Tableau des Échinides, p. 412, 1837.
MICRASTER MURCHISONI, *Morris.* Catalogue of Brit. Fossils, p. 55, 1843.
— — *Bronn.* Index Palæontologicus, p. 724, 1848.
HEMIASTER INÆQUALIS, *Forbes.* Morris's Catalogue of Brit. Foss., 2 ed., p. 81, 1854.
— MURCHISONIÆ. *Forbes.* Mem. of Geol. Surv., decade v, pl. ix, 1856.
— — *Desor.* Synopsis des Échinides Foss., p. 369, 1857.
— MURCHISONIANUS, *De Loriol.* Échin. Helv. Cretacés, t. ii, p. 374, pl. xxxii, figs. 4—6, 1873.

Diagnosis.—Test cordiform, often much inflated, length and breadth nearly equal; round, and largely grooved before, contracted behind, and obliquely truncated on the posterior border. Upper surface convex, declining to the anterior side, and having an obtuse carina on the single inter-ambulacrum; anteal sulcus wide and deep; the pairs of petaloid ambulacra unequal in length, and forming deep depressions on the upper surface, periprocte oval, opening high on the border. Ambulacral summit excentral, posterior to the disc.

Dimensions.—A. Height, $1\frac{4}{10}$ths inch; long., $1\frac{7}{10}$ths; lat., $1\frac{7}{10}$ths.
B. Height ?; long., $1\frac{8}{10}$ths; lat., $1\frac{7}{10}$ths.
C. Height, $\frac{9}{10}$ths; long., $1\frac{4}{10}$ths; lat., $1\frac{4}{10}$ths.
D. Height, 1; long., $1\frac{3}{10}$ths; lat., $1\frac{3}{10}$ths.

Description.—I have given the dimensions of four typical specimens of this Urchin to show its relative proportions. A, the figured specimen, belongs to the British Museum, and B, C, D are in my cabinet. A is a very globose form, and B and C are fair types. In all the specimens the test is very well preserved, and there is no trace of a peripetalous fasciole on any one of them, so I have removed it from the Hemiasters and placed it in the genus *Echinospatagus*.

Professor Edward Forbes studied the specimens of this Urchin in the British Museum, and recorded his measurements in the following memorandum. Further, he noted that

they differed from each other considerably in form, and in degree of depth of the dorsal ambulacra and the number of the pores in the zones.

	A.	B.	C.
Length	$1\frac{8}{10}$	$1\frac{1}{12}$	$1\frac{1}{24}$.
Breadth	$1\frac{8}{12}$	$1\frac{2}{12}$	1.
Height	$1\frac{3}{12}$	$0\frac{11}{12}$	$0\frac{8}{12}$.
Anterior single ambulacrum . . .	28 pairs	26	24.
Antero-lateral pair „ . . .	43 pairs	36	30.
Postero-lateral pair „ . . .	20	22	16.

The anteal sulcus in which the single ambulacrum is lodged is deep, wide, finely granulated and tuberculated. The pairs of pores are arranged on the sides of the area in single files, and the pores forming a pair are separated from each other by distinct tubercles.

The antero-lateral pair are doubly flexed, and the postero-lateral pair, slightly bent, are about half their length. The floors of all the areas are nearly smooth, and the pores, with their small transverse slits in the zones, are set at short distances apart. The portions of the test between the petals form obtuse eminences near the apical disc, that body reposing at the confluence of the five valleys. On these inter-ambulacral elevations the tubercles are more numerous and set closer together than on other portions of the upper surface, fig. 1 *a* and fig. 1 *c*.

The apical disc is small, and composed of four perforated, ovarial plates; the right antero-lateral is the largest, and supports the madreporiform tubercle on its surface. The five ocular plates are very small, fig. 1 *g*.

The surface of the plates is finely granulated, among which there are developed many well-formed tubercles; these become more numerous on the sides, they increase in size and number at the ambitus, and are large and set closely together at the base, on the plastron of which they are very conspicuous, fig. 1 *b*.

Mr. Bone copied fig. 1, Pl. LX, from Decade V, pl. ix, 'Memoirs of the Geol. Survey.' In this figure, drawn under the direction of Professor Forbes, a portion of the surface adjoining the right postero-lateral ambulacrum was magnified to show the diffused condition of the fasciole. As I have carefully examined many very good tests of this species without observing such a structure, I am convinced that a mistake was committed, which my friend unfortunately imported into Pl. LX, fig. 1 *f*, of this work, as no true fasciole exists in this species.

The base is flat or rounded, and the peristome situated at the anterior fourth of the under surface; the tubercles on this region are very large, they are raised upon crenulated bosses, and their summits are perforated; the areola is surrounded by a chain of granules, which completely incircle the areolar boundaries (fig. 1 *i*).

Affinities and Differences.—This Urchin is well characterised by its large and deep anteal sulcus, its bi-flexed antero-lateral ambulacra, the small postero-lateral pair, and

the very excentral position of the ambulacral summit, which is situated behind the centre of the upper surface (fig. 1).

Locality and Stratigraphical Position.—This species is found in the Upper Greensand of Blackdown, Devon, where it is the only Urchin of frequent occurrence, and I have no record of its discovery in any other Upper Greensand locality.

ECHINOSPATAGUS COLLEGNII, *Sismonda*, 1843. Pl. LXIV, fig. 4.

TOXASTER COLLEGNII,		*Sismonda.* Sugli Echini foss. del Contado di Nizza, p. 21, pl. i, figs. 9—11, 1843.
—	—	*Agassiz et Desor.* Cat. raisonné des Échinides, p. 132, 1847.
—	BRUNNERI,	*Merian.* In Desor's Synopsis foss. Échinides, pl. xl, figs. 2—4, p. 354, 1857.
ECHINOSPATAGUS COLLEGNII,		*d'Orbigny.* Pal. Française, Ter. Crétacé, t. vi, p. 169, pl. lcccxlvi, 1853.
—	—	*Cotteau.* Échinides des Pyrénées, p. 52, 1863.
—	—	*Cotteau.* Échinides de l'Yonne, pl. lxiv, fig. 11, t. ii, 1865.
—	—	*Ooster.* Synop. Échin. Suisse, pl. xxv, fig. 8, 1865.
—	—	*De Loriol.* Échin. Helv. Crétacés, t. ii, pl. xxx, figs. 1—5, p. 350, 1873.

Diagnosis.—Test largely cordiform; a little polygonal; rounded, flattened, and slightly depressed anteriorly; contracted behind and obliquely truncated on the posterior border. Upper surface convex, inflated at the posterior half, and much declined from the apical disc to the anterior border. Highest point at the ridge behind the apical disc. Posterior border quadrate, high, strongly and obliquely truncated. Base feebly convex in the region of the plastron, and depressed near the mouth. The lateral parts of the ambitus inflated.

Dimensions.—Length 2 inches and 2 tenths; breadth 2 inches and 1 tenth; height 2 inches.

Description.—This large fine Urchin was given to me several years ago by my late lamented friend Dr. S. P. Woodward, with the remark that it was said to have been collected from the Upper Greensand, Wiltshire, but the species was unknown to him, so he begged me to figure and describe it when I came to the group.

The test is large, cordate, and slightly polygonal, much elevated behind, and sloping from the summit to the anterior border.

The single ambulacrum is lodged in a large, wide, anteal sulcus, deeper above than at the anterior border, which it depresses only feebly; its poriferous zones are narrow; the pores are nearly equal in size, and set obliquely in pairs.

The antero-lateral ambulacra are subpetaloidal, unequal, and lodged in considerable depressions of the test. The anterior pair are the largest, and slightly flexed. The poriferous zones are unequal in width, the inner being the narrowest. The external zone is nearly as wide as the interporiferous space. The pores in both rows are nearly equal in size, and are each connected with slitlike depressions of the test. The posterior pair are shorter than the anterior. They are nearly as wide and diverge at an angle of 45°; their poriferous zones are nearly equal, and a considerable horizontal ridge separates the pair. The plates of the test are sparsely provided with small perforated tubercles, which are all raised upon crenulated bosses and surrounded by circular areolas, and the intertubercular surface is covered with a fine close-set microscopical granulation.

The apical disc is excentral, placed nearer the posterior than the anterior border, in a depression at the ambulacral summit; from this point the test developes a ridge which extends to the posterior border, and the highest point of the test is found one quarter of an inch behind the apical disc.

The posterior border is very much elevated; it appears to have a quadrate form, is sharply truncated, and almost vertical. This portion of the test is unfortunately broken, and it is from the remaining outline that the diagnosis is made. The vent was placed high up on the border, but only one side of the periprocte remains to indicate the position of that opening.

The base is flattened in the region of the plastron; it is slightly convex, and near the oral region is concave. The mouth-opening, situated at the junction of the anterior with the middle third, is transversely oval or subpentagonal; the tubercles on the base are larger than those on the upper surface. On the plastron they radiate from a central point near the posterior border, and have a very symmetrical arrangement on the anterior half; around the mouth they are larger and more sparsely distributed, whilst around the anterior border and the ambitus they are again more numerous.

Affinities and Differences.—I have grave doubts about this Urchin being a British fossil. The matrix differs from the rock in Wiltshire, which usually yields the Upper Greensand fossils of that county, and therefore I record it with reservation; it certainly is the *E. Collegnii* of Sismonda so well figured by Désor in plate 40, figs. 2 to 4, of his admirable Synopsis. Unfortunately I have no authentic specimen of this species with which to compare it, although I have no doubt as to its identity with the form referred to.

Stratigraphical Position.—Said to have been collected from the Upper Greensand of Wiltshire. I have no confirmatory evidence of the fact, and give it with proper reservation.

ECHINOSPATAGUS RENEVIERI, *Wright*, nov. sp. Pl. LXXV, fig. 1.

Diagnosis.—Test cordate, much inclined and depressed, the antero-posterior equalling the transverse diameter; ambulacral pairs petaloidal, unequal in length and structure, and lodged in slight depressions. Anterior pair much flexed; poriferous zones nearly equal, the inner a little narrower than the outer row; posterior pair short, curved; zones equal. Ambulacrum wide, lodged in a deep depression. Test elevated in posterior half and tapering behind to a point; anterior half sloping rapidly to anterior border; base flat.

Dimensions.—Length 1 inch and 4 tenths; transverse diameter 1 inch and 4 tenths; height 8 tenths of an inch.

Description.—This Urchin was catalogued by the late Dr. Fitton as *Holaster complanatus* in his lists of fossils from the inferior beds of Lower Greensand exposed at Atherfield, Isle of Wight. A careful examination of all our Neocomian Echinides, however, has proved that, although *H. complanatus* forms a leading fossil in the Lower Neocomian strata of France and Switzerland, it has never yet been found in England. I have searched carefully most of the public and private collections to find an English specimen, but hitherto without success. Any so-called examples that I have found in the cabinets of my friends were in reality foreign specimens purchased from dealers.

The outline of *E. Renevieri* is peculiar, it being as broad as it is long, and terminating behind in a pointed process. This character at a glance distinguishes it; but when added to others which I shall now point out it renders the difference wider at each step of the demonstration.

The ambulacral pairs are petaloidal and lodged in depressions, whereas in *H. complanatus* they are superficial. The anterior pair are gently flexed, and the poriferous zones are nearly of the same width; the posterior pair are short and curve inwards, and have equal-sized poriferous zones. The ambulacrum is lodged in a wide anteal sulcus, which is deeper above than at the border. The poriferous zones consist of equal-sized holes placed in oblique pairs.

The apical disc is small, and the ambulacral summit excentral; it is much nearer the posterior than the anterior border, and the highest point in the test is on an elevation immediately behind the apical disc. The posterior third of the upper surface is considerably elevated, and the two anterior thirds slope gradually to the border, which imparts a marked character to the test.

The posterior border is narrow and obliquely truncated downwards and inwards. It is unfortunately covered up with a very hard matrix, which cannot be removed without risk to the specimen.

The base is flat and partially covered, and the position of neither the mouth-opening nor the vent is shown.

Affinities and Differences.—It certainly resembles some specimens of *Toxaster complanatus*, but differs from all in the form of the test, being as broad as it is long; its greatest transverse diameter is about the middle of the test. From this point the anterior portion of the ambitus maintains its rounded outline, whilst the posterior portion rapidly contracts to form the narrow truncated posterior border.

The pairs of petaloidal ambulacra are lodged in depressions of the test, whilst they are quite on the general surface without depressions in *T. complanatus*. The conical elevated portion of the upper part of the posterior border is likewise very different from the broadly truncated posterior border in *T. complanatus*. For these reasons I have grouped it with the *Echinospatagi*, and dedicated the species to Professor E. Renevier, of Lausanne, who collected the specimen at Shanklin, Isle of Wight, and gave it to our mutual friend Monsieur De Loriol, to whose cabinet it belongs.

Locality and Stratigraphical Position.—Found in the inferior beds of Lower Greensand at Shanklin, Isle of Wight, in the hard grey sandy rock with numerous oolitic grains of silicate of iron, and which contains fine specimens of *Gryphæa sinuata* and *Ostrea carinata*, with the Echinides *Clypeopygus Fittoni*, Wr., and *Enallaster Fittoni*, Forb. It is, therefore, derived from one of the richest Urchin-beds of the Neocomian series in the Isle of Wight.

ECHINOSPATAGUS QUENSTEDTII, *Wright*, nov. sp. Pl. LXXV, fig. 2.

Diagnosis.—Test cordate. Upper surface convex, very much declined, length and breadth nearly equal. Ambulacral pairs unequal, lodged in shallow depressions. Anterior pair lanceolate, not flexed; form an angle of 40°. Posterior pair short; form an angle of 45°. The poriferous zones of both pairs equal. Ambulacrum long, anteal sulcus shallow, poriferous zones not longer than the anterior pair, only grooving the anterior border very little. Ambulacral summit excentral, situate at the junction of the posterior with the middle third. Posterior border truncated concavely. Flanks sloped inwards. Base small, flat; mouth-opening transversely oblong near the ambitus. Vent high up in the border; periprocte oblong; upper point extending to the beak-like process of the test.

Dimensions.—Length 2 inches and 1 tenth; breadth 2 inches and 2 tenths; height at vertex 1 inch and 2 tenths.

Description.—This Urchin was collected from the fine sandy calcareo-micaceous beds of Lower Chalk or Upper Greensand in Wiltshire; it is always more or less completely denuded of the plates of its test, and is found in the form of moulds. The fineness of

the matrix fortunately produces a very sharp cast of the interior, and as the shell was very thin the outline of its structure is very well preserved.

The ambulacral pairs form quite a "crux Andreæ" on the convex surface of the highly inclined dorsal surface. They were lodged in very shallow depressions, and pass nearly straight out from the summit to the ambitus. The anterior pair are lanceolate and moderately long, and the posterior pair short, extending half the distance between the disc and the border. The poriferous zones in both pairs are nearly equal. The single ambulacrum lies in a shallow anteal sinus, which scarcely grooves the anterior border.

The ambulacral summit is extremely excentral, the disc being near the junction of the posterior with the middle third.

The upper surface is convex and very much inclined. The posterior third is the highest, and the two anterior thirds slope sharply down to the border forming an angle of 20°.

The anterior border is thin, the sides inflated, and bevelled away towards the base and posterior border, which is truncated concavely, and has a portion of the upper surface overhanging it above. In this beak-like projection the vent is situated. The periprocte is oval, the upper end reaching near to the border.

The base is flat. The mouth-opening is situated near the border, and the peristome is narrow and transversely oval; the plastron is a little convex near the border.

Affinities and Differences.—This species resembles *E. Renevieri* in its cordiform outline and highly inclined upper surface. It differs, however, in the shallowness of its ambulacrum and in the absence of depressions for the petaloidal ambulacra, which are straight in *E. Quenstedtii* and flexed in *E. Renevieri*.

Locality and Stratigraphical Position.—The only two specimens I have obtained were collected from the fine marly micaceous beds of the Upper Greensand of Wiltshire.

I have dedicated this species to Professor Aug. Quenstedt, of Tübingen, whose magnificent works on the Cephalopoda, Echinodermata, and 'der Jura' of Würtemburg have so greatly advanced the palæontology of the Jurassic Formations.

Genus.—Enallaster, *d'Orbigny*, 1853.

Hemipneustes, *Forbes*, 1852 (non Agassiz, 1836).
Toxaster, *Roemer*, 1850 (non Agassiz).
Enallaster, *De Loriol*, 1873.

Test more or less cordiform.

Ambulacral summit subcentral.

Ambulacral pairs subpetaloidal, unequal, and depressed.

Poriferous zones in the anterior pair unequal. The posterior zones are much larger and wider than the anterior zones. In the small short pair of posterior ambulacra the poriferous zones are equal.

The anteal sulcus wide. Single ambulacrum, one third wider than the laterals, has narrow poriferous zones, in which each pair of holes are set well spaced out and disposed very oblique to each other; a small tubercle rising from the surface of the partition wall between the pores divides them, and developes an ornamental beaded line on each side of the area.

Apical disc small, compact, with four perforated ovarial and five perforated ocular plates.

Mouth near the anterior border. Peristome subpentagonal, with well-defined margin.

Vent in the middle of the truncated posterior border. Periprocte oval, with well-defined margin.

Enallaster Fittoni, *Forbes*, 1852. Pl. LXV, figs. 1 *a—f*, 2 *a—c*.

Hemipneustes Fittoni,	*Forbes.*	Mem. Geol. Surv., decade iv, pl. v, note, 1852.
—	—	*Forbes. Morris.* Catalogue of British Fossils, 2 ed., p. 82, 1854.
Enallaster Fittoni,	*Désor.*	Synopsis des Échinides fossiles, p. 357, pl. xl, figs. 5—7, 1857.
—	—	*Jaccard.* Jura Vaudois et Neuchatelois, p. 134, 1869.
—	—	*De Loriol.* Échin. Helv. Crétacés, t. ii, p. 359, pl. xxx, fig. 9, 1873.

Diagnosis.—Test oval, cordiform, rounded and sinuous before, contracted behind,

and obliquely truncated posteriorly. Upper surface convex, elevated, and declining towards the anterior border; base flat, with peristomal depression. Sides rounded and inflated, ambulacral summit excentral, and posterior; periprocte oval, situated high up in the border.

Dimensions.—Antero-posterior diameter one inch and $\frac{4}{10}$ths; height, one inch; transverse diameter, one inch and $\frac{5}{20}$ths.

Description.—The test is sometimes cordiform, tapering slightly from the anterior third to the posterior border; in other specimens it is oval, its greatest diameter being about the middle of the ambitus, from whence it diminishes anteriorly and posteriorly. The anteal sulcus is shallow, and the pairs of ambulacra are unequal in length and not much depressed (fig. 1 *a*).

The antero-lateral pair are only partially petaloid, they are long, wide, and depressed in their upper third, are arched above and divergent below. The poriferous zones are very unequal, the anterior are very narrow and composed of small, oblong, almost equal pores, each pair being disposed obliquely circumflex (fig. 2 *c*).

The posterior are much larger, and formed of elongated pores, of which the external are nearly twice as long as the internal series, and there are about 36 pairs of pores in the petaloid portion of each row. The postero-lateral ambulacra are much shorter and more symmetrical in structure, and their poriferous zones are nearly equal; there are about 16 pairs of pores in the petaloid parts of each row. The anterior single ambulacrum is lodged in a shallow anteal sulcus, and is wider than the antero-lateral pair. It preserves a nearly uniform width throughout, and is composed of small plates, which become gradually contracted vertically throughout its upper half (fig. 2 *b*), a character which appears to be generic rather than specific in all the Enallasters that have passed through my hands.

In the lower half of the areas the plates are large, square, or oblong; they are each perforated near their lower and outer corners by a pair of minute approximated pores. In the upper half of the area the plates become narrow, and the poriferous zones are here very conspicuous; each pair of pores is set obliquely in a kind of circumflex manner with a prominent tubercle marking the divisional partition between them (fig. 2 *b*), a singular character which was not well shown in the figured specimen, although it is well marked in others in which the tubercles of the test have been preserved. The surface of the plates is covered with minute granulations, closely set together in transverse rows.

The apical disc is small and compact, the four genital plates are perforated, and the right antero-lateral extends into the middle of the disc, with the madreporiform body on its surface; the elements of the disc are closely blended with the areal plates (fig. 2 *b*).

Peristome subpentagonal and lodged in a depression; it is encircled by a smooth border, and is elongated transversely (fig. 1 *b*).

The periprocte is small and oval, and opens at the summit of the truncated posterior border, within a smooth, undefined, anal area (fig. 1 *a* and *d*).

The tubercles are very small, and developed chiefly on the sides and base (fig. 1 *b*), on the convex upper surface they are nearly absent (fig. 1 *a*); they are largest on the anterior and lateral portions of the base (fig. 1 *b*), and on the plastron they are more regularly arranged; the miliary granules are very small, and set closely together over the surface of the plates and around the tubercles, as seen in fig. 1 *f*, where two large plates and a portion of one of the ambulacral areas is magnified three diameters.

Affinities and Differences.—It is distinguished from *Enallaster Greenovii* by a smaller and narrower anteal sulcus, and by a difference in the structure of the antero-lateral ambulacra, the size of the poriferous zones, and the form of the pores therein.

Locality and Stratigraphical Position.—This species has been collected from Horse-ledge Point, near Shanklin, Isle of Wight, from beds of Lower Greensand, where it is very rare. I have found it in beds of the same age at Atherfield, and it is a leading fossil of these beds in the Island. It has been collected from the Lower Greensand at Hythe. My friend M. De Loriol gives La Presta (Neuchatel), Sainte-Croix (Vaud.), as localities in Switzerland, where it is collected from the yellowish marl belonging to the Étage Aptien inférieur.

ENALLASTER GREENOVII, *Forbes*, 1852. Pl. LXIV, figs. 2 *a—f*, 3 *a—d*.

HEMIPNEUSTES GREENOVII, *Forbes*. Mem. Geol. Surv., Decade iv, pl. v, 1852.
— — — In Morris' Catalogue British Foss., 2 ed., p. 82, 1854.
ENALLASTER GREENOVII, *d'Orbigny*. Paléont. Française, Terrains Crétacés, tome vi, p. 183, pl. 849, 1855.
— — *Désor*. Synopsis des Echinides Foss., p. 358, 1858.

Diagnosis.—Test cordiform, enlarged and sinuous before, contracted and truncated behind; upper surface convex, and declined towards the anterior border. Anteal sulcus large, and wider in the middle. Antero-lateral ambulacra long, biflexed; poriferous zones unequal; internal row formed of small, simple, close-set pores. Postero-lateral pair of short zones equal; posterior border obliquely truncated; periprocte in the upper third.

Dimensions.—Fig. 1. Antero-posterior and transverse diameters 1 inch and 4 twelfths; height 1 inch.

Fig. 2. Antero-posterior and transverse diameters 1 inch and 1 twelfth; height 8 twelfths of an inch.

Description.—This interesting Urchin has a regularly cordate outline, nearly as wide as long, rounded and sulcated anteriorly, and bluntly truncated posteriorly. Its tumidity

varies in different specimens, and the posterior is always higher than the anterior half of the test. The sides are much inflated, and the base is slightly convex (figs. 2 *a* and 2 *b*).

The anterior single ambulacrum is a third wider than the pairs. According to Forbes it preserves nearly a uniform width, and is composed of plates which become contracted vertically throughout the upper half (fig. 2 *a*). Out of the thirty-seven plates seen in each of its two series the lower seven are square or oblong and large (fig. 2 *f*). They are each perforated near their outer and lower corners by a pair of minute approximated pores. In the narrow plates above these a very curious change takes place in the avenue arrangements for the pairs of pores; all become conspicuous, are alternately approximated, and set widely apart, the latter pairs each consisting of a long outer pore and a shorter inner one (fig. 2 *f*). Inside of the pores there is a very small tubercle or two on each plate, the rest of the surface being covered by minute and closely set granulations ranged in transverse rows. The antero-lateral ambulacra are undepressed and superficial, and exhibit a slight and graceful curve; they are composed of an inner series of minute and approximated pairs of pores, and an outer or hinder series in which the pores of each pair are widely separated and unequal (the outer ones being the longest), and connected by a shallow groove. There are about thirty pairs of pores in the petaloidal portion of each series; the petals are also plain and undepressed, but are more regularly lanceolate in shape in consequence of the two series of pairs of pores in each being of nearly similar structure and but slightly unequal in width. There are about eighteen pairs in each petaloid avenue. A few tubercles (fig. 3 *b*) are seen upon the lateral ambulacra. On the interambulacral spaces they are much more numerous though set well apart and much larger. They are largest on the anterior segments, where they have wide areolæ (fig. 3 *c*). Their interstices over the whole of the test are occupied by minute granules, which are, however, not so small or so regularly arranged as those on the odd ambulacral plates. On the under surface the tubercles are confined for the most part to the interambulacral spaces, and are especially numerous, regular, and closely set on the ovato-lanceolate post-oral space formed by the inferior portion of the hinder ambulacrum (fig. 2 *b*). This space exhibits a prominent caudal gibbosity. The tubercles are minute and perforated; they are elevated upon crenulated bosses (fig. 3 *d*). The tracks of the ambulacra are naked. The spines are unknown.

The apical disc is small, and is composed of four perforated genital plates, the perforations of which are approximated. In the midst of them is seen the madreporiform body. A fifth genital plate is imperforate; the five ocular plates are all perforated, but very minute (fig. 2 *f*).

Affinities and Differences.—It very much resembles *E. Fittoni* in its form, outline, and tumidity. It is, however, a larger Urchin, with larger tubercles on the upper surface, and having them more sparsely distributed on the plates.

Locality and Stratigraphical Position.—The specimens I have figured are in the Museum of the Royal School of Mines, and are the same which were so beautifully

drawn by Mr. C. R. Bone for my late esteemed colleague Professor Edward Forbes, whose accurate description I have adopted. They were collected from the Greensand of Blackdown in Devonshire, a formation whose geological horizon is probably about the junction of the Gault and Upper Greensand, and I am not aware the species has been found in any other locality.

Family 13.—Echinocoridæ, *Wright*, 1856.

The Urchins of this family have an oval, cordate, or conoidal test, which often attains a considerable size.

The ambulacral areas are equal, narrowly lanceolate, and converge to one ambulacral summit, which is always the vertex of the test.

The poriferous zones are narrow, and the pores are disposed in pairs at some distance apart.

The surface of the plates of both areas has in general two horizontal rows of very irregular, small, perforated tubercles, raised upon bosses with crenulated summits, and having around their bases a circle of very small granules; the entire surface of the plates in some well-preserved tests is likewise covered with a profusion of similar microscopic granulations.

The mouth-opening is always placed near the anterior border; it is transversely oblong, and often bilabiate; the vent is round, and opens either at the base, near the margin, or in a supra-marginal region of the posterior border in different genera.

The apical disc is usually narrow and much elongated; it consists of four perforated and one unperforated ovarial plate, with five perforated oculars: the whole of the elements are well soldered together, and often covered over with a thin granulated layer of the test, which conceals the sutures of the disc and converts the whole into a single mass. In the genus *Stenonia* the apical disc is short and compact; it is likewise small in *Holaster* and *Cardiaster*, and large and elongated in *Echinocorys*.

The cordate forms have an anteal sulcus feebly shown in *Holaster*, but largely developed in *Cardiaster*, whilst in the conoidal forms, as *Echinocorys* and *Stenonia*, it is absent. In the genus *Cardiaster* there is a marginal fasciole, which passes under the periprocte.

The Echinocoridæ are an extinct family of the cretaceous period, and the species are distributed throughout all the rocks of this formation from the Neocomian strata up to the beds of uppermost White Chalk. One living form which connects this family with the Spatangidæ ought, perhaps, to be placed here, the genus *Palæopneustes*, Agassiz, a singular Urchin which was dredged near Barbadoes by the Hassler expedition.

The extinct genera are:

Echinocorys, *Breynius.*	Holaster, *Agassiz.*
Stenonia, *Desor.*	Cardiaster, *Forbes.*

All the extinct genera are found in British rocks with the exception of *Stenonia*, which is collected only in the White Chalk of Italy, or *Scaglia* of the Vicentin, at Monte di Magre. The living genus Pæopneustes, *Agassiz*, has at present an "incertum sedis" in this group.

Genus—Cardiaster, *Forbes*, 1850.

Spatangus, *Auctorum.*
Holaster (pars), *Agassiz.*
Infulaster, *Borchards.*

Test cordate, tumid, or depressed; lateral ambulacra having the upper part of their avenues slightly dissimilar; all the ambulacra convergent on the vertex, the anterior single ambulacrum lodged in a strongly marked anteal sulcus with angulated borders. A fasciole passing beneath the vent and continued on the sides. Apical disc elongated, and composed of four perforated genital and five perforated ocular plates. Tubercles perforated, raised upon crenulated bosses, and surrounded by areolæ.

Cardiaster possesses all the characters of Holaster, from which it is distinguished by the presence of a subanal fasciole, and a deeper anteal sulcus with more angulated sides.

Cardiaster Benstedi, *Forbes*, 1852. Pl. LXVI, figs. 3 *a*, *b*, *c*; Pl. LXXI, figs. 4 and 5.

Cardiaster Benstedi, *Forbes.* Mem. of Geol. Survey, decade iv, pl. ix, notes, 1852.
— — *Morris.* Catalogue Brit. Foss., 2nd edit., p. 73, 1854.

Diagnosis.—Test cordiform, broad, hemispherical, upper surface convex, rotund, anteal sulcus shallow, lateral ambulacra narrow, poriferous zones narrow and unequal.

Dimensions.—Length one inch and a half; breadth one inch and a half; height one inch.

Description.—The anteal sulcus is strongly marked and wide below. The upper surface is gently curved, convex, and rotund. The poriferous zones are all remarkably narrow, and the posterior as broad as the antero-laterals. Pl. LXVI, fig. 3 *a*, represents the upper convex surface, showing the very narrow zones with the central apical disc and its four

perforated ovarial plates. Fig. 3 *b* gives a lateral view, showing the increased elevation at the anterior third, and fig. 3 *c* shows the position of the vent with its oval periprocte in the posterior border. Pl. LXXI, figs. 4 and 5 are figures of this Urchin from the Lower Greensand of the Isle of Wight. This species was first described by Professor Edward Forbes in the 'Memoirs of the Geological Survey,' decade iv, in his notes on British species of Cardiasters appended to his description of pl. ix. It was collected from the Lower Greensand of Maidstone, and presented to the Royal School of Mines Museum by Messrs. E. H. Bunbury and Professor Morris. The specimens were too imperfectly preserved to be described. The one that forms the subject of our figure in Pl. LXVI belongs to the collection of the British Museum, and I understand it was collected from the same rock and locality.

The test is broad, cordate, and hemispherical, convex on the upper surface, and inflated at the sides. The anteal sulcus is wide below and shallow in the upper part; the ambulacrum smooth in the middle, with a row of tubercles on each side of the angles; the pores are minute, remotely placed in oblique pairs; the antero-lateral ambulacra are narrowly lanceolate; the poriferous zones contracted, and the pores are like fine slits set wide apart; the postero-lateral pair are about the same width but shorter than the anterior pair. The surface of all the plates is covered with a minute, close-set granulation, and at the anterior border a few irregular rows of larger tubercles are developed. The back is gently curved towards the upper angle of the vent, which occupies the middle of the posterior border (Pl. LXVI, fig. 3 *b, c*, and Pl. LXXI, fig. 4 *d*).

The base is much distorted in most of the specimens, appears to have been flat and had numerous rows of large tubercles set upon the central plastron, and the sides and anterior portion.

The mouth-opening is situated near the anterior border; it is transversely oblong and bilabiate (Pl. LXXI, fig. 4 *b*), the peristome is, unfortunately, displaced in the specimens that have come into my hands.

The apical disc is small, consisting of four pairs of perforated ovarials and five perforated ocular places (Pl. LXXI, fig. 4 *a*; Pl. LXVI, fig. 3 *a*).

The posterior border is small, narrow, and truncated (Pl. LXXI, fig. 4 *d*; Pl. LXVI, fig. 3 *c*), and the vent opens in its upper portion.

Affinities and differences.—This species, originally proposed by Professor Edward Forbes for an Urchin from the Lower Greesand of Maidstone, which he considered to be distinct from any other species, is characterised by the following diagnosis:—"*C. late cordatus, subhemisphæricus, dorso rotundato, seriebus pororum omnibus angustis subequalibus.* The anterior sulcus is strongly marked and wide below. The back is gently curved. The vent is medial in position as compared with its height. The poriferous avenues are all remarkably narrow, and the hinder ones as broad as the antero-laterals. The surface of the test is too imperfectly preserved to be described." Since the date of this description several specimens have been found in the Lower Greensand at Atherfield,

Isle of Wight, in nodules from the Walpen and Ladder Sands and Clays, with *Gryphœa sinuata* and *Ammonites* (*Hoplites*) *Martini*, d'Orbigny, and in the bed with *Gryphæa* at Shanklin Point, where several other Urchins, as *Clypeopygus Fittoni*, Wright and *Echinospatagus Renevieri*, Wright, have been found. The affinities of this species are certainly with *Cardiaster fossarius*, the smaller forms of which it closely resembles in many points of structure. The narrowness of the poriferous zones, common to both forms, cannot afford a specific character; therefore, until better examples are found for comparison, I must regard the distinction between *C. Benstedi* and *C. fossarius* as doubtful.

Locality and Stratigraphical Position.—In the Lower Greensand of Maidstone, and in the Lower Greensand at Shanklin and Atherfield, Isle of Wight.

CARDIASTER LATISSIMUS, *Agassiz*, 1840. Pl. LXVII, figs. 1, 2 *a—h*.

HOLASTER LATISSIMUS,	*Agassiz.*	Catalogus Syst., p. 2, 1840.
— —	*Agassiz et Desor.*	Cat. Raisonné, p. 133, 1847.
— —	*d'Orbigny.*	Prodrome, t. ii, p. 177, 1847.
— —	*d'Orbigny.*	Paléont. Française, Ter. Crét., tom. vi, p. 92, pl. 837 and 838, 1853.
CARDIASTER SUBORBICULARIS,	*Forbes.*	Mem. Geol. Surv., decade iv, pl. ix, notes, 1852.
— —	*Morris.*	Catal. Brit. Foss., p. 73, 1854.

Diagnosis.—Test cordiform, broader than long, much depressed; anterior border very wide, deeply grooved by the anteal sulcus, sides expanded; posterior half contracted and becoming rapidly narrow behind, upper surface slightly convex; anterior half more rotund and elevated than the posterior half, which developes a ridge between the disc and the posterior border, this region is narrow, elevated, and obliquely truncated, having the vent high up near the dorsal surface. Ambulacral pores narrow, poriferous slightly unequal. Anteal sulcus deep, ambulacrum with very minute round pores. Base slightly convex, depressed near the mouth, convex and elevated in the middle and posterior region over the plastron.

Dimensions.—Large specimen, fig. 1. Antero-posterior diameter two inches and $\frac{7}{10}$ths; transverse diameter two inches and $\frac{8}{10}$ths; height $\frac{11}{10}$ths of an inch.

Small specimen, fig. 2. Antero-posterior diameter two inches and $\frac{2}{10}$ths; transverse diameter two inches and $\frac{3}{10}$ths; height anteriorly $\frac{8}{10}$ths of an inch, posteriorly $\frac{9}{10}$ths of an inch.

Description.—This beautiful Cardiaster is entered in our catalogues of British Urchins as *C. suborbicularis*. It appears, however, to be identical with *Holaster*

latissimus, Agassiz, so well figured in the 'Paléontologie Française.' A careful comparison of the two fine specimens before me, which formed the subjects of our plate, with three specimens of *C. orbicularis* from the Étage Cénomanien de Cap-le-Hêve, shows that *Cardiaster latissimus* is more depressed and proportionately wider to its length than the specimens of *C. suborbicularis* from Havre measured by me. Moreover, in the latter the under surface is more convex, and the plastron ridged, and the posterior border more elevated than in our English specimen. I have lately had the advantage of examining at Auxerre my friend Monsieur G. Cotteau's magnificent collection of recent and fossil Echinodermata, and of comparing *Cardiaster orbicularis* and *C. latissimus* with each other, and find that his type-specimens of the latter species are identical with the Echinide I have figured under that name from the Upper Greensand of Dorsetshire.

The body is cordiform and much depressed, it is rounded before, and deeply grooved by the anteal sulcus, the sides are widely expanded, and the posterior border is contracted and acuminated. The upper surface is convex and a little more elevated at the anterior than at the posterior third; a ridge rising along the middle line from the disc backwards gives a marked character to the smaller specimen (figs. 2 *b* and *c*). The pairs of ambulacra are unequal. The anterior pair are slightly curved outwards and forwards, and the posterior are shorter and directed straight outwards and backwards (figs. 1, 2 *b*). The poriferous zones are narrow, and composed of small equal-sized holes (fig. 2 *e*). The anterior single area is lodged in a deep sulcus, the zones are feebly developed, and the holes very minute (fig. 2 *f*). The surface of the plates, especially those about the anterior border and the base, has a number of small tubercles developed on their surface (figs. 2 *a* and 2 *e*). The tubercles are mammillated, with crenulated bosses and perforated summits (fig. 2 *g*). The apical disc is small and elongated, with four perforated ovarial plates (fig. 2 *h*) and five small oculars.

The under surface (fig. 2 *a*) is flattened, a little convex in the region of the plastron, and concave at the sides and around the anterior border. The mouth-opening is placed in a depression near the junction of the anterior fourth with the middle fourths of the base. The peristome is small and bilabiate (fig. 2 *a*). The arrangement of the tubercles on the base is very well shown in this drawing, which gives a more correct notion of their comparative size and distribution than any description can convey.

The vent is situated high up in the posterior border (fig. 2 *c*), which is narrow and truncated obliquely downwards and inwards (fig. 2 *b*), with a beak-like process overhanging the upper angle of the vent, the periprocte of which has an oval form (fig. 2 *c*).

Affinities and Differences.—I have already pointed out the affinities and differences subsisting between this species and *C. suborbicularis;* there is no other congeneric form in our Upper Greensand strata with which it can be confused; it is altogether a very rare form in our area.

Locality and Stratigraphical Position.—The large specimen was obtained from the

Upper Greensand of Golden Cap, near Bridport, on the Dorsetshire coast, and the small specimen from the Cowstones, Upper Greensand, at Black Ven, near Lyme Regis, Dorset, and all the other British specimens on record were collected from the same beds on the Dorset coast. It appears, however, to be a very rare form in that county.

In France it is found in the Cénomanien at Havre, and at Grand-Prè, Meuse, and Ardennes, in the same étage.

The specimen in the Royal School of Mines, Jermyn Street, is from the Upper Greensand of the neighbourhood of Osmington, in Dorsetshire, where it was obtained by Mr. E. H. Bunbury, who presented it to the Museum of that Institution.

CARDIASTER FOSSARIUS, *Benett*, 1831. Pl. LXVIII, figs. 1 *a*—*e*.

SPATANGUS FOSSARIUS,	*Benett.*	Catalogue of Upper Greensand Fossils, p. 7, 1831.
HOLASTER GREENOUGHII,	*Agassiz and Desor.*	Cat. Raisonée, p. 133, 1847.
MICRASTER FOSSARIUS,	*Morris.*	Catalogue of Brit. Foss., p. 54, 1843.
CARDIASTER —	*Forbes.*	Mem. Geol. Surv., decade iv, pl. ix, notes, 1852.
— —	*Forbes.*	Morris's Catalogue, 2 ed., p. 73, 1854.
— —	*D'Orbigny.*	Paléontologie Française, Ter. Crétacé, tome vi, p. 124, pl. 820, 1855.

Diagnosis.—Test large, cordiform; length and width nearly equal, greatest diameter at the anterior third; deeply grooved at the anterior border, with prominent marginal carinæ, much elevated anteriorly and contracted posteriorly; the highest point of the test behind the ambulacral summit; posterior border truncated; base slightly convex, with an elevated ridge on the plastron, periprocte in the upper part of the border having a blunt carina extending from its upper part to the disc; test covered with very small tubercles.

Dimensions.—Antero-posterior diameter, $2\frac{6}{10}$ inch; transverse diameter, $2\frac{6}{10}$ inch; height, $1\frac{7}{10}$ inch. This is the size of the large figured specimen. Smaller tests which I have measured bear the same relation in their several diameters to each other as that given for the type.

Description.—This is the fine Wiltshire *Cardiaster* long ago mentioned in Miss Benett's 'Catalogue of Wiltshire Fossils' as *Spatangus fossarius*. A specimen of this species was sent by Mr. Greenough to the Paris Museum, which was entered in Agassiz and Desor's 'Catalogue Raisonné' as *Holaster Greenoughii*. It has been long a leading fossil Urchin in the Upper Greensand of Wilts, and appears to be special to that English formation, as I have not found any specimen approaching this form from the Cenomanian

Stage on the Continent. The test is largely cordiform, having the length and breadth of nearly equal diameters; the anterior border is convex, with a deep anteal sulcus, having sharply defined carinal borders extending upwards towards the apical disc; the summit of the ridges forming the sides of this sulcus attain the highest point in the test. The posterior half of the shell tapers considerably towards the posterior border, which is narrow, truncated, and depressed. The sides and border are slightly angular from the way the broad plates forming the interambulacra areas are bent, and this angularity imparts a very marked character to the tests of this Urchin. Figs. 1 *a* and *c* show these angles fairly well.

The ambulacral areas are of unequal width; the anterior pair are the longest and largest, and extend across the test; their poriferous zones are unequal, as the inner series have the pores more nearly approximated than those of the outer series; the apertures have the form of narrow slits, and the pairs of pores are placed close together in the upper part of the zones, but become wider asunder as the discal distance increases, so that at the middle of the side they are much wider apart, and on the lower part of the ambitus quite remote from each other (figs. 1 *a*, *c*).

The posterior pair of ambulacra are much shorter and directed backwards; the pores in their zones are likewise in the form of slits, and become in like manner wider asunder as they descend the area. The ambulacra and poriferous zones are in no way depressed, and occupy the surface of the test (figs. 1 *c*, *d*).

The inter-ambulacral areas are very wide, and built up of long plates, which are bent transversely near their middle; this bending of the plates produces the angles in the test already referred to; between the antero- and postero-lateral ambulacra the angles are marked out by a series of knotty lines along the sides of the test, and a similar ridge runs between the antero-lateral ambulacra and the prominent sides of the anteal sulcus, so that the angularity of the test is an interesting character of this species.

The upper surface is covered with very minute tubercles, which become a little larger on the anterior border and are still larger on the sides of the anteal sulcus.

The apical disc is small, and well soldered into the plates of the test; there are four perforated ovarials, and five ocular plates.

The under surface is convex and angular; the plastron forms a prominent ridge, which divides the posterior half along the mesial line, and it becomes concave at the anterior third where the mouth is situated (fig. 1 *b*); the basal plates are covered with larger tubercles, which have a well-defined arrangement on the plastron and on the lateral parts of the base (fig. 1 *b*).

The mouth-opening is near the anterior border; it is a wide opening, transversely oblong, with a well-defined peristome and rudimentary labial process.

The vent is oval, and situated in the upper part of the posterior border, which is depressed (fig. 1 *d*); two ridges extend vertically along the sides of the border, and increase the depth of the concavity in which the periprocte is placed, producing a beak-

shaped projection at the superior part of the border where the two carinæ meet above the vent as seen in profile in fig. 1 *e*.

Affinities and Differences.—This species is well characterised by its large, deep, anteal sulcus, angular upon the sides, where it is sharply defined by its two carinæ, and prolonged from the peristome below to the apical disc above by these boundary ridges arising from the folds of the test. These characters added to the height of the test with its angular circumference easily distinguish it from *Cardiaster latissimus*, and the same group of characters readily mark it out as a very distinct form from *Cardiaster granulosus* and *C. bisulcatus*.

Locality and Stratigraphical Position.—This species has been collected only from the Upper Greensand of Wiltshire; it was formerly an abundant fossil in these beds; but has, however, now become scarce; fine specimens with the test in good preservation are seldom found. The large shells I have figured belonged to Mr. Cannington's collection, and were collected many years ago. These grand specimens now belong to the British Museum.

CARDIASTER PEREZII, *Sismonda*, 1843. Pl. LXVIII, fig. 2 *a*, *b*, *c*.

HOLASTER PEREZII,	*Sismonda.*	Sugli Ech. Foss. di Nizza, p. 11, pl. i, figs. 1—3, 1843.
—	—	*Agassiz and Desor.* Catalogue Raisonné des Échinides, p. 135, 1847.
—	—	*Albin Gras.* Oursins Fossiles de l'Isére, p. 62, 1848.
—	BISULCATUS,	*Albin Gras.* Oursins Fossiles de l'Isére, p. 62, pl. iv, figs. 7, 8, 1848.
—	PEREZII,	*d'Orbigny.* Prodrome, t. ii, p. 141, 1850.
—	—	*d'Orbigny.* Paleont. Française Ter. Cret., p. 86, pl. dcccxiii, figs. 1—7, 1853.
CARDIASTER BISULCATUS,	*Forbes.*	Mem. Geol. Surv., decade iv, pl. ix, Notes on Cardiasters, 1852.
—	—	*Morris.* Catalogue of British Fossils, 2nd ed., p. 73, 1854.
HOLASTER PEREZII,	*De Loriol.*	Echinid. Helvétique Ter. Cret., p. 325, pl. xxvii, figs. 6—8. 1873.

Diagnosis.—Test convex, enlarged before, contracted behind, elevated anteriorly to the ambulacral summit, and gradually inclined from thence to the posterior border, anteal sulcus short, deeply indenting the anterior border, antero-lateral ambulacral narrowly lanceolate; postero-lateral ambulacra short and wide; posterior border accuminated and oblique, vent low down in a small truncated area, periprocte oval. Primary tubercles very small in proportion to the size of the test, a dorsal carina extending from the vertex to the border; apical disc small, situate at the junction of the anterior, with the middle third of the upper surface.

Dimensions.—Antero-posterior diameter two inches and one tenth ; transverse diameter two inches ; height one inch and one tenth.

Description.—In notes to a list of British Cardiasters appended to a description of pl. ix, decade iv, of the 'Memoirs of the Geological Survey of the United Kingdom,' Professor Edward Forbes says, "in the Museum of Practical Geology there is a *Cardiaster* from the Greensand of Blackdown, remarkable for the small tubercles in proportion to its size and the great width of the hinder lateral poriferous avenues. It seems to be identical with the *Holaster bisulcatus*, described and figured by M. Albin Gras in his 'Oursins fossiles de l'Isére.'" I had a very careful drawing of this rare Urchin made from the type specimen, and placed it (fig. 2 *a*, *b*, *c*) on the same plate with *C. fossarius*, to show its near affinity with that form.

The test is cordate, about as long as it is wide; the anterior border is elevated (fig. 2 *b*) and deeply indented (fig. 2 *a*) by the anteal sulcus, which is well defined by the angular folds bounding the depression on both sides (fig. 2 *c*) ; the central portion of the ambulacrum is smooth and the pairs of pores minute and distinct from each other. The antero-lateral ambulacral pairs (fig. 2 *a*) are short, narrowly lanceolate, and the postero-lateral pair wider behind ; the poriferous zones of all the avenues are narrow, and their pores are small slit-like apertures. The ambulacral summit is near the anterior border of the junction of the anterior with the middle third of the test. The apical disc which occupies this point is small, compact, and formed of four perforated ovarial and five minute ocular plates. The surface of the plates carry very small tubercles in proportion to the size of the test, a well-marked character originally pointed out by Forbes. A few larger tubercles occupy the angles of the sulcus and anterior border, but on the other portions of the upper surface they are very uniformly diminutive. The posterior border much accuminated above (fig. 2 *a*) and obliquely truncated inwards below (fig. 2 *b*) ; the anal area is very limited, and the oval periprocte opens at the top of the oblique truncature of the posterior border.

Affinities and differences.—*Cardiaster Perezii* resembles *C. fossarius* in many of its essential characters ; it differs, however, in some minor points in the anatomy of its test ; the posterior half is much more accuminated, the anal area much smaller, the upper surface is likewise more inclined from the vertex of the border than in *C. fossarius*. The tubercles are smaller on the upper surface, but larger, and more developed at the base. The continental authorities as MM. d'Orbigny, Cotteau, and De Loriol, consider this Urchin as a true *Holaster*. In deference to the opinion of my lamented colleague Professor Edward Forbes I have left it in the genus in which he placed it.

Locality and Stratigraphical Position.—This Urchin is very rare in England, and has been collected only from the Upper Greensand at Blackdown with *Echinospatagus Murchisonianus*. In France it is found in the Gault at Ravis (Isere), and at Clar near Escragnolle. In Switzerland, Perte-du-Rhône, Sainte-Croix (Vaud), Wannealp, Oberalp (Wæggithal), Cheville, Bossetan (Valais), and in France, near Nice.

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ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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ON THE ECHINOCORIDÆ.

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CARDIASTER PYGMÆUS, *Forbes*. Pl. LXIX, figs. 1 *a*—*e*.

CARDIASTER PYGMÆUS,	*Forbes*.	Ann. Nat. Hist., 2nd ser., vol. vi, p. 444, 1850.
—	— *Forbes*.	Mem. Geol. Surv., decade iv, pl. ix, notes, 1852.
—	— *Morris*.	Catal. of Brit. Foss., 2nd ed., p. 73, 1854.

Diagnosis.—Test very small, ovate, and cordate; anterior channel large; ambulacral areas wide, sparsely covered with microscopic tubercles; posterior border truncated vertically; periprocte in the upper third; upper surface gently rounded, with an elevated carina between the apical disc and the upper margin of the periprocte.

Dimensions.—A middle-sized specimen measured in the antero-posterior diameter half an inch; in the transverse diameter five twelfths of an inch, and in height four twelfths of an inch. It is found, however, that the proportions vary considerably.

Description.—This small *Cardiaster* is common in the Chalk at Dover, where many good specimens were collected several years ago by Major C. F. Cockburn, R.A., who kindly supplied examples for this work. The outline of the test is ovate, gently rounded on the upper surface (Pl. LXIX, figs. 1 *d*, *e*), and provided with a subcarinated ridge, which rises behind the apical disc (fig. 1 *a*), and extends backwards to the upper border of the periprocte (fig. 1 *d*). The anteal sulcus is wide (figs. 1 *a*, *e*) and strongly carinated, and the posterior border is sharply truncated (fig. 1 *c*); the oval periprocte opens in the upper third (fig. 1 *d*); the sides of the test are moderately inflated (figs. 1 *e* and 1 *c*), and the view from the base shows the ovato-cordate ambitus of this beautiful little Urchin (fig. 1 *b*).

The ambulacral areas are acutely lanceolate on the upper surface, the antero-lateral curve a little backwards, and the postero-lateral pass direct to the disc; the poriferous avenues are very narrow, and the pores in single pairs are set closely together.

The surface of the test appears to be perfectly smooth. When examined with a lens, however, it is seen to be covered with minute granules, among which a number of primary tubercles of small size are scattered (fig. 1 *a*, *b*, *c*).

The base is flat at the sides, and has a central elevated ridge, which extends from the peristome to the posterior border (fig. 1 *c*, *b*); the mouth is transversely oblong, and situated near the anterior border (fig. 1 *b*).

Affinities and Differences.—This Urchin when magnified two diameters, as it is in our figures, has a striking resemblance to *Holaster lævis*; but differs in having the anteal sulcus deeper and wider, its sides more angular, and the posterior border broader and more sharply truncated than in that species; the mouth is also nearer the anterior border.

Locality and Stratigraphical Position.—This small Urchin has hitherto been found only in the Upper White Chalk at Dover, Kent, and was first briefly noted by the late Prof. Edw. Forbes, F.R.S., in the 'Ann. and Mag. of Nat. History,' 2nd series, December, 1850.

CARDIASTER ANANCHYTIS,[1] *Leske.* Pl. LXIX, figs. 2 *a*—*i*, 3.

SPATANGUS ANANCHYTIS,	*Leske.*	Addit. ad Kleinii Echin., p. 243, pl. liii, figs. 1, 2, 1778.
ECHINUS ANANCHYTIS,	*Gmelin.*	Sytema Naturæ, p. 3199, No. 97, 1789.
— —		Encyclopéd. Méth., Mollus. et Zooph., Atlas, pl. clvii, figs. 7—10, 1791.
ANANCHYTES CORDATA,	*Lamarck.*	Anim. sans vertèbres, t. iii, p. 26, No. 8, 1816.
SPATANGUS GRANULOSUS,	*Goldfuss.*	Petref. Germaniæ, p. 148, pl. xlv, fig. 3, 1826.
— —	*Desmoulins.*	Études des Échinides, p. 410, 1835.
— CORDIFORMIS,	*Woodward.*	Geol. of Norfolk, p. 50, pl. v, fig. 6, 1833.
HOLASTER GRANULOSUS,	*Agassiz.*	Prodrome, p. 16, 1836.
— —	*Agassiz & Désor.*	Cat. Rais. des Échinides, in Ann. des Sc. Nat., 3rd. ser., vol. viii, p. 27, 1847.
— ÆQUALIS,	*Portlock.*	Geol. Rep. Londonderry, p. 355, pl. xvii, 1843.
— CORDIFORMIS,	*Forbes.*	Ann. Nat. Hist., 2nd ser., vol. vi, p. 443, 1850.
CARDIASTER GRANULOSUS,	*Forbes.*	Mem. of the Geol. Survey, decade iv, pl. ix, 1852.
— ANANCHYTIS,	*d'Orbigny.*	Paléont. Franç. terr. Crétacés, t. vi, p. 131, pl. 826, 1853.
— GRANULOSUS,	*Forbes.*	Morris Catal. of Brit. Foss., 2nd ed., p. 73, 1854.
— ANANCHYTIS,	*Desor.*	Synops. des Échin. Foss., p. 345, pl. xxxix, figs. 7—9, 1857.
— —	*Coquand.*	Bull. Soc. Géol. France, 2e sér., tom. xvi, p. 1010, 1860.
— —	*Cotteau.*	Échinides du Dép. de la Sarthe, p. 237, pl. li, fig. 2—5, 1860.
— GRANULOSUS,	*Schluter.*	Foss. Echinoderm. des nördlichen Deutschlands Verh. d. Nat. Vereins der Rheinl. und Westphal., Jahrg. xxvi, Folge iii, Band vi, p. 251, 1869.

Diagnosis.—Test regularly cordate; upper surface in one variety depressed, in another more elevated. Primary tubercles large and conspicuous on each side of the anteal sulcus, which is wide and deep; posterior border narrow and obliquely truncated.

Dimensions.—This Urchin grows to a considerable size. The fine figured specimen is two inches and seven tenths of an inch in length, two inches and four tenths of an inch in breadth across the widest part of the ambitus, and one inch and four tenths of an inch in height at the vertex. Other specimens have greater height in proportion to their breadth, or greater length in proportion to their width, and others are higher and more convex on the upper surface, or are flatter and more depressed throughout.

The French specimens collected in the Sarthe, according to Mons. Cotteau, vary much in their proportional dimension. *Var. major.*—Antero-posterior diameter 43 milli-

[1] Termed in error Cardiaster granulosus on the explanation of figs. 2 and 3, Plate LXIX.

mètres; transverse diameter 42 millimètres; height 26 millimètres. *Var. minor.*—Antero-posterior diameter 27 millimètres; transverse diameter 25; height 15.

Description.—This elegant Urchin has a regularly cordate ambitus. It is deeply channelled in front by the anteal sulcus, which has sloping walls, with angulated borders above, and a deep granulated channel below. The greatest breadth of the test is immediately behind the antero-lateral ambulacra; from this point it slopes gently towards the posterior border, which is very narrow, and slightly truncated downwards and inwards.

The upper surface is convex, very much rounded before, and declining gently behind. The under surface is very much depressed near the mouth, and slightly convex in the single inter-ambulacrum, which has a sinuous ridge along the middle line, with nodular elevations at each alternate angle. The vertex is nearly central. The anteal sulcus is deeply hollowed out from the summit to the mouth, especially at the ambitus, and is circumscribed laterally and superiorly by angulated carinæ. The single ambulacrum is lodged in the sulcus, and composed of very small round pores, separated by a granuliform elevation, and situated in a small, smooth, lanceolate fossa, very narrow above and expanded below. The pores are close together above, and widen as the plates become larger. There are about twenty-eight plates visible in a full-grown specimen. The antero-lateral ambulacra are subpetaloid in their upper part, and unsymmetrical, in consequence of the pores of each pair being wider apart in the outer row than in the inner, and, moreover, being united by a deeper groove. There are about twenty-four pairs of pores in the subpetaloidal portion. They are closely approximated, and those that are below widen out; the outer series is likewise slightly arcuated. In the postero-lateral ambulacra the two series are nearly similar, and there are about eighteen pairs of pores in the subpetaloid portion. There are about nine plates in each series in the dorsal portion of the lateral inter-ambulacral segments, and ten above the vent in the posterior segment. The infra-anal portion of the latter is composed of two series of five irregularly polygonal plates each. They are remarkable for presenting gibbosities at regular intervals. In the inferior portions of each postero-lateral ambulacrum there are seven plates in each series. These are polygonal, large, and elongated, and bear the pairs of pores, which are minute and oblique, close to their inner angles. The pores of the ambulacra around the mouth form an obscure star.

The surface of the plates is profusely covered with very fine granules, which observe a very regular arrangement among them. Two sets of tubercles of unequal size cover the plates at regular distances apart; the small tubercles, which are seated among the granules of the upper surface (fig. 2 *f*), and the large tubercles, which are perforated and crenulated, are seen on the upper surface around the apical disc, upon the middle of the single inter-ambulacrum, and upon the borders of the anteal sulcus (fig. 2 *e*). In the infra-marginal region and along the central space on each side of the sinuous ridge (fig. 2 *b*), they are large and conspicuous. Each of the large tubercles is elevated upon a boss

with a crenulated summit, on which is placed a perforated tubercle (fig. 2 *l*). Very fine, close-set, homogeneous granules are prolonged horizontally between the pairs of pores in the poriferous zones, and likewise fill up the anteal sulcus, which is completely deprived of primary tubercles (fig. 2 *e* and *d*).

The apical disc is narrow, solid, and elongated, and so closely covered with the small granules that its elements are concealed. In many specimens it is composed of four ovarial and five perforated ocular plates. The anterior ovarials are small, and the madreporiform tubercle is quite rudimentary. The postero-laterals are long, and separated from the antero-laterals by two perforated oculars, so that the three anterior ambulacra are rather widely separated from the two posterior ambulacra (fig. 2 *d*).

The vent opens very low down in the narrow, posterior, triangular border. The periprocte is widely oval, and surrounded by numerous small granules (fig. 2 *d*).

The marginal fasciole is more or less distinct in different specimens. It passes under the periprocte, and runs out upon the sides towards the convex portion of the ambitus. It is narrow, and free from intermingled tubercles (fig. 2 *g*), and it is only well seen in very good specimens.

The base is flat, and the mouth situated near the anterior border in a depression formed by the deep grooving of the anteal sulcus, where it turns round the anterior border (fig. 2 *b*, *e*). The peristome consists of a convex upper lip and a prominent under lip. A few tubercles make a radiate ornamentation about the upper lip (fig. 2 *b*).

Affinities and Differences.—*Cardiaster ananchytis* is well distinguished from its congeners by its cordiform outline dilated before and subangular behind, by its deep anteal sulcus deprived of tubercles, by the poriferous zones very unequal in the antero- and postero-lateral pairs, by the large tubercles which show themselves sparsely on the upper surface, and by the low position of the periprocte.

History.—Leske (1778) first figured an imperfect specimen of this Urchin under the name of *Spatangus ananchytis*, and Lamarck afterwards called it *Ananchytes cordata*. Goldfuss figured it under the name of *Spatangus granulosus*, and *S. orbicularis*. Mr. Samuel Woodward, in his 'Geology of Norfolk,' figured it as *Spatangus cordiformis;* and then succeeded the various changes of name which have been already noted in the synonymy of the species. It is, however, to M. d'Orbigny's quick perception that we are indebted for first identifying Leske's figure with the subject of this article.

Locality and Stratigraphical Position.—First identified as a British Urchin by Mr. S. Woodward, who stated that it was rare in the Upper Chalk at Harford Bridge, and common in the Medial Chalk at Swaffham and Thetford, Norfolk. General Portlock has found and described it as *Holaster æqualis* in the Chalk of Londonderry.

Foreign Localities.—It has been collected in France, where it is rare, at Château-du-Loir, Teiffe, Duneau, Villedieu, Sarthe; Tours, Indre-et-Loire; Lauquais, Dordogne; Meudon, Seine: at Ciply, Belgium; Langelsheim, Brunswick; Haldem, Westphalia, in North Germany: it is found in the Upper and Lower Senonian.

Genus—INFULASTER, *Hagenow* MSS., 1851.

CARDIASTER, *Forbes*. 1852.
INFULASTER, *Desor* (with diagnosis). 1858.
— ZITTEL. 1879.

Test narrow, oblong, of an irregular ovato-cordate form. Anterior half very much elevated, rising into a prominent vertex, situated nearly above the anterior border; the anteal sulcus narrow, deep, and directed obliquely downwards and backwards, with two prominent angular borders, which rise above the upper surface. Plates smooth, covered with very small granules; a few primary tubercles near the vertex and at the sides, and in the centre of the under surface; a sub-anal fasciole is seen only on some fine specimens.

INFULASTER EXCENTRICUS, *Rose*. Pl. LXX, fig. 1, *a*—*k*.

SPATANGUS EXCENTRICUS, *Rose*. Woodward's Geol. of Norfolk, p. 27, pl. i, fig. 5, 1833.
CARDIASTER EXCENTRICUS, *Forbes*. Ann. Nat. Hist., 2nd series, vol. vi, p. 443, 1850.
— — *Forbes*. Mem. of Geol. Surv., decade iv, pl. x, 1852.
— — *Morris*. Catal. of Brit. Foss., 2nd ed., p. 73, 1854.

Diagnosis.—Test long, ovato-cordate; upper surface considerably elevated anteriorly and declining much to the posterior border; anteal sulcus deep, narrow subvertical; vertex very excentric; posterior border obliquely truncated, forming a triangular space, in which the periprocte occupies the upper angle.

Dimensions.—Antero-posterior diameter one inch and eight tenths of an inch; transverse diameter one inch and four tenths of an inch; height one inch and three tenths of an inch. These are the measurements of the large specimen figured in Pl. LXX, most kindly given to me by my friend the late Mr. Rose many years ago for this work.

Descriptions.—This singular Urchin has long been one of the greatest rarities of the Norfolk Chalk. When viewed in profile it presents the singular form seen in Pl. LXX, fig. 1 *c*; the high vertex nearly overhangs the anterior border, and the upper surface slopes away at an angle of 30° towards the posterior border which is truncated obliquely downwards and outwards, and imparts another odd feature to the test.

The dorsal surface is very high anteriorly (fig. 1 *c*), and the walls of the anteal sulcus rise nearly perpendicularly to the highest part of the body (fig. 1 *d*, *e*) immediately in front of the apical disc (fig. 1 *a*). From the point of its greatest elevation the upper surface gradually declines nearly in a straight line (fig. 1 *c*, *i*), forming a long sub-carinated ridge, which extends to the upper part of the posterior border (fig. 1 *d*), at about half the height of the test at the vertex. On each side of the ridge the upper surface slopes away rapidly (fig. 1 *d*), but the sides are rounded, and, in the antero-lateral regions, tumid (fig. 1 *e*). The posterior border forms a triangular space (fig. 1 *c*, *d*, *i*); which is obliquely truncated, and has the periprocte opening in its upper angle surrounded by a circle of tubercles two rows deep (fig. 1 *d*).

The under surface is convex in the antero-posterior, and transverse diameters, so that the under surface of the body is gently rounded in all directions; on the cheeks at the base a few primary tubercles are observed (fig. 1 *b*), and on the plastron another grouping of like tubercles is placed.

The single ambulacrum is lodged in the deep anteal sulcus, but the poriferous zones are scarcely discernible in good specimens. The lower half of the depression is rounded and covered with minute granules, among which no indications of pores can be seen with a hand magnifier; in the upper third they are small, indistinct, and closely set together, and are best seen where the uppermost portion of the area curves backward to meet the apical disc (fig. 1 *a*, *c*). Here we see a few pairs of small round pores, arranged in a vertical series, and the single ambulacrum articulating with the disc a little in advance of the antero-lateral ambulacra; these are placed very far forward and extend over the most tumid part of the sides of the test (fig. 1 *c* and *i*). The pores are very small (fig. 1 *a*). Forbes counted on a large specimen thirty pairs of pores in these rows between the apex and the margin; in my figured specimens only twenty can be identified. The avenues or poriferous zones are at the surface of the test, and the pairs of pores of the outer rows are a little wider than the inner one. The postero-lateral ambulacra are even less conspicuous (fig. 1 *c*, *d*); they diverge greatly from the antero-laterals, and form together a very acute angle. Their uppermost portion consisting of closely-set pores. On their posterior portions the pairs of pores become very indistinct.

The apical disc is small, narrow, and elongated (fig. 1 *k*). There are four perforated ovarial plates in the middle, and five very small perforated ocular plates at the summits of the areas; all the parts of the disc are very solid and firmly joined into the other elements of the test.

The mouth is situated near the anterior border (fig. 1 *b*) at the point where the anteal sulcus terminates, it therefore lies in a depression. It is a small opening with a round or transversely oblong peristome; the anterior lip is smooth, and the posterior more developed.

The vent is situated in the upper third of the truncated posterior border (fig. 1 *d*). The periprocte is vertically oval and of large size (fig. 1 *d*); its upper half is surmounted

by an arch of small tubercles, three tiers or more in depth, whilst the lower surface of the border is closely covered with small granules, among which a few small tubercles scattered here and there are seen.

The body-plates of the test are throughout covered with very fine close-set granules, and amongst these several small tubercles are disposed, from six to nine on each plate; at fig. 1 *f*, eight plates from the sides of the test have been carefully drawn and enlarged three diameters; in order that this arrangement on their surface, which is clearly demonstrable in good specimens, may be shewn, for on these only can the structure be discerned.

The plates on the margins of the anteal sulcus are thickly studded with large primary tubercles (fig. 1 *c*, *e*), which are raised on bosses with crenulated summits, and surmounted by perforated tubercles (fig. 1 *g*). The areolæ around the bosses are encircled by granules; tubercles similar to these in form and structure are seen on the cheeks of the shell, and a few are extended along the sides and on the central plates of the rounded base (fig. 1 *b*).

Forbes described the fasciole as "distinctly marked, passing under the vent and continued on each side, even over the cheeks." Some indications of this fasciolar track were drawn by my artist, who noted his impression in fig. 1 *h*; but I have seen nothing that I would call a fasciole, such as we observe in Hemiasters, Micrasters, &c., in any of the forms that have come under my examination.

Locality and Stratigraphical Position.—This remarkable Urchin, with which I know nothing to compare, was first observed by my old friend Mr. C. B. Rose, of Swaffham, and communicated by him to Mr. Samuel Woodward, in whose 'Geology of Norfolk' it was first figured from specimens collected from the Upper and Medial Chalk of Norfolk.

Affinities and Differences.—*Infulaster excentricus*, Rose, very much resembles *Infulaster Hagenowi*, Borchards, collected from the White Chalk of Staffin, in the Island of Wollin, Pomerania. A model in wax was communicated to Professor d'Orbigny by Herr von Hagenow, in 1851, without any other indication of publication. A comparison of specimens would alone enable the observer to decide on the affinities and differences of the German as compared with the Norfolk form; seeing that one of the specimens given me by Mr. Rose very much resembles *Infulaster Hagenowi*, Borchards.

INFULASTER ROSTRATUS, *Forbes*. Pl. LXX, figs. 2, *a—f*; 3 *a*.

Diagnosis.—Test much compressed on the sides; anteal sulcus long, deep, and narrow, its sides rising high into a beak; dorsal surface curved and carinated; posterior border obliquely truncated, bent in upper third; sub-anal fasciole, well defined, and extended on the flanks.

As I have been able to obtain only fragments of this Urchin, too imperfect for description, I shall transcribe the account which my late esteemed colleague Professor Edward Forbes, F.R.S., gave of it in the 'Memoirs of the Geological Survey' decade iv, p. 3, 1852.

"For some time," says Forbes, "I was under the impression that this extraordinary and anomalous little Urchin, of which specimens were kindly communicated by Dr. Bowerbank, Mr. Wetherell, and Mr. Woodward, was the young of the *Cardiaster excentricus*, different as its outline is. The series of specimens of various sizes of the latter shown me by Mr. Rose convinces me that it is necessary to regard this beaked and *Neæra*-like form of *Cardiaster* as distinct. All the examples are impressed with the same peculiarities. The number submitted to me has been seven, including fragments; and in addition to those lent for examination are two fine specimens, one of them nearly entire, found by Mr. Cockburn, in the Chalk-with-Flints, at Bostal Heath, near Plumstead, and generously presented by that gentlemen to the Museum of Practical Geology.

"The striking feature of this form is the rhomboidal profile which it exhibits in consequence of the obliquity of the anteal and posteal truncations, both inclining forwards at considerable angles (fig. 2 *a*—*e*). The anteal ambulacral sulcus is very deep, long, and narrow; it rises obliquely to a great height in consequence of the elevation of the apical disk upon a sort of beak (fig. 2 *e*). The genital plates are assembled just below its summit, which is notched by the turning over, as it were, of the anteal furrow. The details of the lateral ambulacra, in consequence of their being completely plane and very obscure, can with difficulty be distinguished; the rostrum bends forward slightly in its upper part. The summit of the back is more or less sharply carinated, and declines rapidly with a faint concave curve, until it terminates in the summit of the very oblique and rapidly declining posterior truncation, in the uppermost part of which, at rather less than the total height of the body, is the anus, placed at one end of a groove. The whole of the dorsal surface of the test is covered with granules interspersed with scattered minute tubercles, which become more numerous on the slightly tumid cheeks. The fasciole is strongly and distinctly marked, and passes from beneath the anus over the cheeks. The base is flattened, and except on the ambulacral spaces is strongly tuberculated. The mouth is very small and far forward."

Dimensions.—The largest specimen measured in length at the base, eight twelfths of an inch; in breadth, six twelfths of an inch; and in height, ten twelfths of an inch at the anteal sulcus.

Locality and Stratigraphical Position. — In the Chalk-with-Flints of Kent and Norfolk.

Genus—Holaster, *Agassiz*, 1839.

Synonym—Spatangus, *Auct.*

The test has an oval or cordiform figure, more or less convex at the upper surface, and, in general, flat at the under surface.

The pairs of antero- and postero-lateral ambulacral areas are petaloidal, superficial, and lanceolate; they are widely apart below, and join each other above.

The poriferous zones are formed of elongated pores (always those in the external rows), disposed by simple pairs, very much separated and regularly superposed on each other, between the ambitus and apical disc. The ambulacrum, or single anterior area, is always lodged in a shallow central sulcus; its pores are very minute and resemble those of the lateral areas. The ambulacral summit is central or subcentral.

The apical disc is solid and elongated; its elements consist of four perforated ovarial plates and five perforated oculars. The genital plates are disposed in pairs, and the anterior are separated from the posterior pair by a pair of ocular plates being interposed between them.

The posterior border is narrow and more or less truncated, and the periprocte, always marginal, opens in general in the upper part of this region. The mouth-opening is situated near the anterior border in a slight depression, and the peristome is transversely oval and imperfectly bilabiate. There are no fascioles on any part of the test.

The shell is very thin, and the surface of the plates is uniformly covered with a very fine granulation; tubercles, more or less developed, appear in irregular order among them. Granules attaining their largest size, in the form of tubercles, appear upon the plates of the inter-ambulacral areas, and on those of the basal region, and this is more especially so in *Holaster Trecensis*, Leym. The ambulacral areas have, however, fewer tubercles than the other areas. The Holasters appertain to the Cretaceous Rocks, and form leading fossils in certain stages of the same; they are most abundant in the Upper Greensand and Lower Chalk, one species only being special to the White Chalk.

There seems to have been an unnecessary amount of confusion in the synonymy of some of the species, arising it would appear more from the copying of names than from the inspection and comparison of the specimens themselves.

In the British Islands we find: *Holaster lævis*, De Luc, in the Upper Greensand and Lower Chalk; *Holaster obliquus*, Wright, in the Upper Greensand and Lower Chalk; *Holaster suborbicularis*, Defrance, in the Chloritic Marl and Lower Chalk; *Holaster lævis*, var. *planus*, Mant., in the Upper Greensand, Lower Chalk, and lower portion of Upper Chalk; *Holaster subglobosus*, Leske, in the Chloritic Marl and Lower Chalk; *Holaster Trecensis*, Leym., in the Lower Chalk; *Holaster pillula*, Lamk., in the Upper Chalk.

HOLASTER LÆVIS, *De Luc.* Pl. LXXII, fig. 1 *a—f.*

SPATANGUS LÆVIS,	*De Luc.*	Cat. Collection, Berne Mus.
ANANCHYTIS CARINATA,	*Lamarck.*	Animaux sans Vertèbres, t. iii, p. 26, 1816.
SPATANGUS LÆVIS,	*Brongniart.*	Descr. Géol. des Environs de Paris, pp. 97 et 399, pl. ix, fig. 12, 1822.
— NODULOSUS,	*Goldfuss.*	Petref. Germaniæ, Band i, p. 149, pl. xlv, fig. 6, 1826.
— —	*Blainville.*	Manuel Actinologie, p. 204, 1834.
— —	*Desmoulins.*	Études sur les Échinides, p. 410, 1837.
HOLASTER LÆVIS,	*Agassiz.*	Descr. des Échinid. Suisses, t. i, p. 17, pl. iii, figs. 1—3, 1839.
— TRANSVERSUS,	*Agassiz.*	Ibid., t. i, p. 18, pl. iii, figs. 4—5, 1839.
— SUBORBICULARIS,	*Agassiz.*	Ibid., t. i, p. 21, pl. iii, figs. 11—13, 1839.
— SANDOZ,	*Agassiz.*	Ibid., t. i, p. 11, pl. ii, figs. 1—3, 1839.
— LÆVIS,	*Agassiz.*	Catal. Ectyp. foss. Mus. Neoc., p. 1, 1840.
— NODULOSUS,	*Agassiz.*	Ibid.
— SUBORBICULARIS,	*Agassiz.*	Ibid.
— —	*Morris.*	Catal. of British Fossils, p. 54, 1843.
— NODULOSUS,	*Morris.*	Ibid., p. 54, 1843.
— PLANUS,	*Morris.*	Ibid., p. 54, 1843.
— LÆVIS,	*d'Orbigny.*	Paléont. Franç., Ter. Crét., t. vi, p. 83, pl. 812, 1853.
— TRANSVERSUS,	*d'Orbigny.*	Ibid., p. 88, pl. 819, 1853.
— CARINATUS,	*d'Orbigny.*	Ibid., p. 104, pl. 818, 1853.
— LÆVIS,	*Renevier.*	Mém. Géol. sur la Perte-du-Rhône, p. 49, 1855.
— —	*Pictet.*	Traité de Paléontologie, 2nd ed., t. iv, p. 192, pl. xciii, fig. 3, 1857.
— CARINATUS,	*Pictet.*	Ibid., t. iv, p. 192, 1857.
— LÆVIS,	*Desor.*	Synopsis, p. 339, 1858.
— —	*Lory.*	Descr. Géol. du Dauphiné, p. 339, 1860.
— CARINATUS,	*Lory.*	Ibid., p. 350, 1860.
— —	*Cotteau.*	Échinides de la Sarthe, p. 195, pl. xxi, figs. 3—5, 1860.
— —	*Cotteau.*	Échinides Foss. de l'Yonne, t. ii, p. 249, pl. lxix, figs. 6, 7, 1865.
— —	*Geinitz.*	Elbthalgebirge in Sachsen i, p. 84, pl. xx, fig. 5, 1871.
— LÆVIS,	*De Loriol.*	Échinol. Helvetique Ter. Crét., p. 319, pl. xxvii, figs. 1—5, 1873.

Diagnosis.—Test oval, cordiform, slightly grooved before, and narrowed a little behind; largest diameter in the middle of the postero-lateral inter-ambulacra. Upper surface in general depressed, sometimes elevated and convex. The middle of the single

inter-ambulacrum (occasionally only) more or less elevated into a carina; under surface flat; peristome near the anterior border. Periprocte oval, situated in the upper part of a small truncated posterior border. Ambulacral summit subcentral, a little nearer the anterior border.

Dimensions.—Antero-posterior diameter one inch and a half; transverse diameter one inch and four tenths; height eight tenths of an inch. These are the dimensions of the average number of adult specimens obtained from the Upper Greensand of Wiltshire.

Description.—The body of this Urchin has a very regular figure, of a cordato-ovate shape, larger before and tapering behind, the largest transverse diameter being across the middle of the postero-lateral inter-ambulacra. The anteal sulcus is very shallow, and the anterior border only slightly depressed; the posterior border is narrow and obliquely truncated a little downwards and inwards.

The upper surface is in general elevated and convex (Pl. LXXII, fig. 1 *b*, *c*, *d*, *e*), and some specimens have the posterior half of the test a little more ridged, and the middle line forming a blunt carina, which has been erroneously considered a specific character by several authors (fig. 1 *c*, *d*).

The ambulacral areas are wide, apetaloid, and disjoined at the summit; the antero-lateral pair are arched backwards and forwards in their upper thirds (fig. 1 *b*), and the postero-lateral pairs slightly bent in the opposite direction (fig. 1 *b*). The single ambulacrum (fig. 1 *b*, *e*) is lodged in a wide, shallow anteal sulcus, the depression from which vanishes in the upper half of its length (fig. 1 *e*), so that the convexity of the dorsal surface is almost complete (fig. 1 *b*). The poriferous zones are narrow, the pores small, closely set in pairs, placed near each other above, and wider apart as they descend the sides. At the under surface the ambulacral areas are large and smooth, and quite superficial. The pores in the single ambulacrum are extremely small, and seen only in very good specimens.

The apical disc is narrow and elongated (fig. 1 *b*). The genital plates, four in number; are arranged in pairs, and between the anterior and posterior pairs one pair of the five ocular plates is interposed by aposition of the discal elements. The apices of the ambulacral areas are disjoined, as seen in fig. 1 *b*.

The base is very flat (fig. 1 *a*), and the ambital border forms an acute angle. The mouth-opening is lodged near the anterior border, in a depression of the test formed by the arching round the angle of the anteal sulcus. The peristome has an oval figure, slightly elongated transversely.

The vent opens at the posterior truncated border, always low down, near the base (fig. 1 *d*). The anal area is a very small, slightly hollowed-out space, the periprocte is oval in a vertical direction, and has a well-defined border.

The surface of all the plates is covered with an extremely fine abundant microscopic granulation, which is preserved in patches on different parts of good specimens;

in those from the Upper Greensand it has entirely disappeared, whilst on some specimens from the Lower Grey Chalk and the Chloritic Marl, its true character may be studied. Fig. 1 *f* shows an enlarged portion of a test, in which the granules existed with several of the primary tubercles interspersed at irregular intervals in the midst of the granulation. Many of the tubercles are raised on finely crenulated bosses, which support small perforated tubercles, accurately drawn in fig. 1 *f*.

Affinities and Differences.—The general form of the test varies much in this species, being more or less depressed or elevated in different examples; still the other characters, which may be considered as specific, remain very permanent in all these variations. The examples collected from the Grey Chalk near Folkestone, and from the Lower Chalk of Sussex, are in general larger and better preserved than the small typical specimens collected from the Upper Greensand at Chute Farm, Wilts. The Chalk specimens have likewise retained many of the large primary tubercles surrounded by patches of the granulated surface, and specimens collected from our Lower Chalk are absolutely identical with a specimen I have from the Craie Chloritée of Cap-le-Hève, near Rouen.

After a careful comparison between the tests of *Hol. lævis* and those of *Hol. carinatus*, and good figures of *Hol. transversus* and *Hol. marginatus*, I agree with my learned friend, Monsieur De Loriol,[1] that they in reality are all so many varieties of *Hol. lævis*, grown under different physical conditions, which have changed only some of the external characters of their original form, but left the essential and specific ones untouched. De Loriol has examined likewise the original example of the true large *Hol. Sandoz*, Agass., contained in the Museum of Zurich, with other examples of the collection of Monsieur Du Bois de Montpéreux, found by him in the Upper Greensand of Souaillon (Neuchâtel), and De Loriol affirms that *Hol. Sandoz* is only a very large and very fine specimen of *Hol. lævis*. Mons. De Loriol unites also *Hol. Trecensis*, Leymerie, with *Hol. lævis*. In Pl. LXXIV, fig. 2, I have given a very good figure of this species, and in page 324 have entered fully into this subject when describing its affinities. *Holaster lævis* differs from *Hol. planus*, Mantell, in some particulars. In *Hol. planus* the test is larger, more oblong and less cordate, and the ambulacral summit subcentral nearer the anterior border; the upper surface is flat and declines very little towards the posterior border, which is only slightly truncated to form an anal area, in the upper part of which the vent opens. *Hol. lævis* resembles likewise *Hol. suborbicularis* in some points of structure, but differs so widely in others that I must refer to my article on that species, and to that on *Hol. subglobosus*, for the affinities and differences existing between them.

Locality and Stratigraphical Position.—The small figured specimen I collected from the Upper Greensand at Chute Farm, Wilts, where it is very common. The tests are so much covered over with adhering sand particles that it is rare to obtain a good specimen. I have collected this species likewise from the Grey Chalk near Folkestone, and from the Lower Chalk, near Lewes, Sussex.

[1] 'Echinologie Helvetique,' p. 324, 1873.

HOLASTER OBLIQUUS, nov. sp., *Wright*. Pl. LXXVIII, fig. 1, *a*—*e*.

Diagnosis.—Test oblong, slightly cordate, greatest width across the anterior third, gradually diminishing in size to the posterior border, which is narrow and obliquely truncated; ambulacral summit excentral near the junction of the anterior with the middle third, upper surface convex and sloping downwards to the posterior margin; anal opening in the upper part; periprocte elliptical; area narrow and inclined downwards and inwards. Base rounded; mouth-opening near the anterior border; anteal sulcus shallow and inclined downwards and inwards; peristome small, transversely oval, unilabiate, and situated in a depression.

Dimensions.—Antero-posterior diameter two inches; transverse diameter one inch and three tenths; vent above the base seven tenths of an inch.

Description.—This rare Urchin has an oval outline; its greatest width is posterior to the antero-lateral ambulacral areas. From this part of the ambitus it tapers obliquely inwards towards the narrow posterior border. The upper surface is convex and the ventral summit, near the apical disc, is situated about the junction of the anterior with the middle third, and to this point all the ambulacral areas converge; from the disc to the posterior border the upper surface inclines obliquely downwards and forms a long slope towards the anal area. The antero-lateral ambulacra are short, straight, apetaloid, and lanceolate, and pass straight upwards from the ambitus to the disc. The postero-lateral ambulacra are straight, lanceolate, and apetaloid; they are much larger than the anterior pair from the excentral position of the summit. The poriferous zones are narrow and superficial; the pores small, and placed in pairs; forty pairs exist between the disc and the ambitus, and below that line they become invisible.

The apical disc is a small, narrow, oblong body, of which the elements are so closely soldered together that the sutures are obliterated.

The mouth-opening is small, and situated at a short distance from the anterior border in a depression formed by the incurving of the anteal sulcus. The peristome is small and transversely oval, and is placed near the junction of the first with the second fourth part of the total basal length of the shell.

The vent opens in the upper part of the posterior border; the anal area is very narrow, and the oval periprocte is situated high up in this space, where the convex portion of the long, obliquely-sloped back bends over the truncated portion of the posterior border.

The surface of the plates is covered with a close-set miliary granulation, which is beautifully preserved in a specimen from the Upper Greensand of Wiltshire. On the larger plates a few small tubercles are developed without much order in their arrangement. Six to eight such tubercles are seen upon many of these plates.

Affinities and Differences.—This species resembles, in many traits of structure, *Holaster lævis.* It is readily distinguished from that species by the ambulacral summit being much more excentral, which occasions a much longer slope between the apical disc and the posterior border, and a greater obliquity of the upper surface of the test; the antero-lateral ambulacra are shorter and straighter, and the postero-lateral pair much longer. The anteal sulcus is likewise shallower, and the posterior border much narrower. The rotundity and smoothness of the test, and the width and shallowness of the anteal sulcus form a marked difference between it and *Holaster suborbicularis,* and the same characters serve to separate it very distinctly from *Holaster subglobosus.*

Locality and Stratigraphical Position.—This Urchin appears to be rare. I have only seen three specimens; two of these were collected from the Lower Chalk near Folkestone, and the third was obtained from the Upper Greensand at Chute Farm, near Warminster, Wilts. I have compared this Urchin with a large number of Holasters from the Chalk of France and Switzerland, in the cabinet of my friend M. De Loriol; and it is easily distinguished from all its congeners by the excentral position of the apical summit, and the long sloping declension of the posterior two thirds of the upper surface. The specific name *excentricus* was at first suggested for this species, but as we have the *Infulaster excentricus* from the Cretaceous Rocks it was better to adopt *obliquus* as indicative of the obliquity of the upper and posterior surfaces of the test, in order to avoid any confusion regarding this new form, which I have now described and figured for the first time.

HOLASTER SUBORBICULARIS, *Defrance.* Pl. LXXIV, figs. 1 *a*—*e*.

SPATANGUS SUBORBICULARIS,		*Defrance.* MS., 1821.
—	—	*Brongniart.* Descrip. géol. Paris, p. 85, pl. v, fig. 5, 1822.
—	—	*Blainville.* Mém. d'Actinologie, p. 204, 1834.
HOLASTER	—	*Agassiz.* Prodrom. d'une Monogr., p. 16, 1836.
—	—	*Desmoulins.* Études sur les Éch. Foss., p. 400, 1837.
—	—	*Deshayes,* in Lamarck, 2nd ed., An. sans Vert., t. iii, p. 334, 1843.
—	—	*Sismonda.* Mém. géol.-zool. Echin., p. 8, 1843.
—	—	*d'Orbigny.* Paléontol. Franç., Ter. Crétacés, t. vi, p. 93, pl. 814, figs. 6, 7; pl. 815, 1853.
—	CENOMANENSIS,	*d'Orbigny.* Ib., p. 111, pl. 819, figs. 7—12, 1853.
—	SUBORBICULARIS,	*Desor.* Synopsis des Echin. Foss., p. 340, 1858.
—	—	*Cotteau.* Échinides de la Sarthe, p. 198, pl. xxxiii, figs. 1—6, 1860.

Diagnosis.—Test oblong, cordiform, rounded and deeply grooved before, contracted

and truncated vertically behind; superior surface elevated and convex on both sides, with a well-marked carina extending from the apical disc to the posterior border; the inferior surface much depressed before, and on each side of the mouth more or less elevated along the region of the plastron, and presenting alternate protuberances and depressions there, so that the greatest height of this species is about the posterior third of the test. Ambulacral summit excentral anteriorly; vent large, situated high up in the anal area.

Dimensions.—Antero-posterior diameter one inch and a half; transverse diameter one inch and three tenths of an inch; height nine tenths of an inch. I have several moulds of this species collected from a siliceous rock in Dorsetshire, which measured more than the figured specimen, obtained from the Chloritic Marl near Chard, and here drawn as our type because its shell is well preserved with many important details of its structure *in situ*. I have two large specimens of this Urchin from the Cap de la Hève. The largest measures two inches and six tenths in the antero-posterior diameter, two and a half inches in the transverse diameter; and one inch and two tenths in height; the second specimen measures two inches and four tenths in length, two inches and three tenths in breadth, and one inch and four tenths in height, so that when we reduce these measurements for comparison with those of the figured specimen, we find the proportions are nearly the same as relates to length, breadth, and height throughout.

Description.—This is a very neat, oblong, cordiform Urchin; the round anterior border is deeply grooved by the anteal sulcus, the widest part of the body is behind the anterior ambulacrum, and from that point backwards the ambitus contracts into the posterior border, which is vertically truncated to form the anal area (fig. 1 *e*).

The antero-lateral ambulacra curve gently up to the disc, and the postero-lateral pair are nearly straight in their course (fig. 1 *a*). The poriferous zones consist of pairs of pores, which are distant from each other below, and approximate above; in some of the larger specimens the pores are oblong below and round above. The anteal sulcus is very deep, extending from the mouth to the apical disc; it is bordered by elevations of the test, which form two carinæ on the sides of the sulcus (fig. 1 *a*, *d*). On these several large tubercles are arranged. The single ambulacrum occupies the middle of the sulcus; its avenues consist of very small pores, which are only visible with the aid of a lens. The three anterior ambulacra converge around the front of the disc, at a considerable distance from the posterior pair, which converge at the hinder part thereof (fig. 1 *a*).

The test is very thin, and the inter-ambulacral areas consist of very wide plates (fig. 1 *c*); their surface in both areas is closely covered with a very fine microscopic granulation, in the midst of which a number of small tubercles, nearly equal in size, are uniformly spaced out upon all the surface of the test. On the sides of the anteal sulcus, and on the cheeks and plastron at the base the tubercles are much larger; they are all raised on bosses with crenulated summits, and are perforated and surrounded by a smooth circular zone, defined by an outer circle of granules (fig. 1 *b*, *d*).

The apical disc is narrow and elongated; its elements consist of four perforated genital plates, on the right anterior of which the small madreporiform tubercle rests between the anterior and posterior pair; two ocular plates are interposed; the single ocular is seen at the summit of the single ambulacra, and the two posterior oculars at the summits of the hinder pair; the elements of the disc are closely united together, and the surface of the plates covered with fine granules.

The vent is large, and opens at the upper part of the anal area immediately below the carina (fig. 1 *e*). The periproctc is elliptical, with a well-defined margin acuminated at both extremities, and having the lower part of the border hollowed out (fig. 1 *e*).

The mouth is transversely oblong, placed near the anterior border in a depression formed by the anteal sulcus. The peristome is transversely oblong (fig. 1 *b*), and is rounded before, with a thickened projecting lip behind. Around the aperture are several pairs of round ambulacral pores arranged in a stellate figure (fig. 1 *b*).

Affinities and Differences.—This Urchin was long a puzzle to palæontologists, and we are indebted to d'Orbigny for having removed the confusion that existed, and for proving that Defrance's Urchin figured by Brongniart was the true type of the species. The English specimens are small, and resemble the Urchin described as *Holaster Cenomanensis*, d'Orb., which, however, is only a small variety of *Hol. suborbicularis*. M. Cotteau is disposed to unite this species to *Cardiaster fossarius*, Bennet, an opinion in which I cannot concur, as I feel satisfied that, if my learned friend had before him good type specimens of *Card. fossarius*, he would readily distinguish the differences between that Urchin and *Hol. suborbicularis*. Putting aside the question of the lateral fasciole, which I have never seen in *Card. fossarius*, the other features of the test are sufficiently distinct to show the differences which exist between them (see Pl. LXVIII).

In *Holaster fossarius* the shell is shorter and broader than in *Hol. suborbicularis*. The anteal sulcus is deeper, and retains its depth from the mouth to the disc, whereas in *Hol. suborbicularis* the sulcus vanishes above the anterior border, and leaves the upper surface smooth and undepressed. The carinæ on each side of the sulcus are more prominent and much sharper in *Hol. fossarius* than in *Hol. suborbicularis*, and the avenues of pores in the antero-lateral ambulacra are wider apart and more petaloid; whilst the base is flatter and the plastron less prominent in *Hol. fossarius* than those parts are in *Hol. suborbicularis*.

Locality and Stratigraphical Position.—This Urchin abounds in the bed of Chalk with green grains intervening between the Upper Greensand and Chalk-Marl. It is found likewise plentifully in the Chalk-Marl itself, and more rarely in the Lower Chalk. It has been collected in nearly all the English Counties in which these beds are found, but has not been observed in Ireland.

The Foreign Distribution.—Villers-sur-Mer, Vaches-Noires (Calvados); Montagne St.-Catherine près Rouen; Fécamp (Seine-Inférieure); Fourneaux, la Madelaine

(Eure); Laubressel, Sainte-Parre près Troyes (Aube); Fourrain, Seigneley, Yonne; Sancerre (Cher); Cassis (Bouches-du-Rhône); Vit près Castellane (Basses-Alpes); Bidart près Biarritz (Basses-Pyrénées); Palarea (Nice); Altmann (Appenzell); Quedlinburg, Prussia; North Germany, &c. In France it has been collected from the zone of *Acanthoceras Rhotomagense*, Brong., and in strata with *Scaphites æqualis* in Conde, Sarthe, which is precisely the same zone from which our English specimens have been collected.

HOLASTER LÆVIS, *var.* PLANUS, *Mantell.* Pl. LXXII, fig 2, *a—f;* Pl. LXXIX, fig. 1 *a*, *b*.

SPATANGUS PLANUS, *Mantell.* Geology of Sussex, p. 192, pl. xvii, figs. 9—21, 1822.
HOLASTER PLANUS, *Agassiz.* Prodrom. Mém. Soc. de Neuchâtel, t. i, p. 183, 1835.
— — *d'Orbigny.* Paléontol. Française, Ter. Crét., t. vi, pp. 116, 821, 1853.
— — *Desor.* Synopsis des Échinides, p. 342, 1858.

Diagnosis.—Test cordate, widest across the middle third, gradually diminishing in width to the posterior border, which is narrow and slightly truncated, anterior border a little depressed by the anteal sulcus. Ambulacral summit subcentral, upper surface convex, gently declining all round towards the ambitus; periprocte in the upper part of the anal area. Under surface flat, plastron prominent, mouth-opening near the border in a small depression, peristome transversely oval and bilabiate. Surface of the test smooth.

Dimensions.—Antero-posterior diameter two inches; transverse diameter one inch and eight tenths; periprocte above the base line seven tenths of an inch.

Description.—This Urchin has a cordate outline, and is widest anteriorly, its greatest transverse diameter being immediately behind the antero-lateral ambulacra; from this point it tapers gently to the posterior border, which presents a narrow truncation. The upper surface is convex, and the vertical summit with the apical disc is subcentral; to this point all the ambulacral areas converge (Pl. XXII, fig. 2 *b*). The antero-lateral pair are short, slightly bent, apetaloid, and lanceolate, they pass obliquely up the sides of the test. The poriferous zones are narrow and superficial, the pores small and placed in pairs; there are forty pairs of holes in each of the avenues above the ambitus, which are entirely invisible below; the postero-lateral pair are equally oblique and lanceolate, and their avenues of pores the same. In the figured specimen there are thirty pairs in each avenue. The single ambulacrum is lodged in a wide, shallow anteal sulcus which only slightly depresses the anterior border and entirely disappears in the upper half of its length (fig. 2 *a*, *b*, *d*).

The apical disc is small, long, and narrow; and its elements are so closely welded together that I have failed to detect the sutures which divide them (fig. 2 *b*).

The under surface is moderately flat about the cheeks and side border; it is elevated in the middle by the prominence of the plastron, and the path of the postero-lateral areas along the base is shown by a wide, smooth surface on each side of the central elevation (fig. 2 *a*).

The mouth-opening is small, situated a short distance from the border in a depression formed by the incurving of the anteal sulcus. The peristome is transversely oval, and placed about the junction of the first with the second fourth of the total basal length of the test (fig. 2 *a*).

The posterior border is very narrow, the anal area small, and the vent opens in its upper part; the oval periprocte is situated high up in this space, near the point where the convex part of the back bends over towards the truncated portion of the posterior border (fig. 2 *e*).

The surface of the plates is covered with a microscopic, close-set, miliary granulation, beautifully preserved and shown in some of the specimens derived from the Grey Chalk. On the larger plates a few small tubercles are arranged without much order, from six to eight of these may be counted upon each of the plates (fig. 2 *b*).

Affinities and Differences.—This species resembles some of the large forms of *Hol. lævis*, from which it differs very little; the ambulacral summit is slightly subcentral, which makes the direction of the ambulacral areas nearly uniformly quinque-radiate on the upper surface, as seen in fig. 2 *b*. The anteal sulcus is shallow, the posterior border narrow, and the position of the periprocte in the anal area is much the same in *Hol. planus* as in *Hol. lævis*. The rotundity and smoothness of the test, and the width and shallowness of the anteal sulcus in *Holaster planus* form marked differences between it and *Hol. suborbicularis*, with which it has sometimes been confounded, and the same characters serve to establish the differences between *Hol. planus* and *Hol. subglobosus*.

Locality and Stratigraphical Position.—This species is said to characterise a well-marked zone of the Lower Chalk at Lewes and Dover, and I have specimens collected from the Medial Chalk at Swaffham, Norfolk, sent by my old friend the late Mr. C. B. Rose. It occurs also in the chalk with flints (in lower portion of the Upper Chalk) near Lewes. The specimen (Pl. LXXIX, fig. 1) from the Collection of the Rev. Thos. Wiltshire, F.G.S., shows that the species was gregarious.

Many geologists express surprise that several species of Echinides are recorded by me as having been found in the Grey Chalk, Lower Chalk, Chloritic Chalk, and Upper Greensand. There can be no doubt about the fact of the presence of this species therein; other forms also have often occurred to me when noting the distribution of species in these beds. It may be suggested whether some artificial divisions, in the natural groupings of the strata, have not been made on petrological rather than on palæontological grounds. If this conjecture should turn out to be correct then the Lower

Chalk and Upper Greensand may be bracketed together, and not separated by a hard-and-fast line as at present.

HOLASTER SUBGLOBOSUS, *Leske*, sp. Pl. LXXIII, figs. *a*—*h*.

SPATANGUS SUBGLOBOSUS,	*Leske.* Add. ad Kleinii Disp. Echin., p. 240, pl. liv, figs. 2, 3, 1778.
ECHINUS SUBGLOBOSUS,	*Linné.* Gmelin's Systema Natura, p. 3198, 1789.
— —	*Lamarck.* Encyl. Method., Zoophytes., pl. 157, figs. 7, 8, 1791.
SPATANGUS SUBGLOBOSUS,	*Lamarck.* Animaux sans Vertèbres, t. iii, p. 33, 1816.
— —	*Deslongchamps.* Encycl. Method., Zoophytes, p. 689, 1824.
— —	*Goldfuss.* Petref. Germaniæ p. 148, pl. xvii, fig. 4, 1826.
— —	*Blainville.* Zoophytes, Dict. Sc. Nat., t. lx, p. 185, 1830.
— HEMISPHÆRICUS,	*Phillips.* Geol. of Yorkshire, p. 91, pl. i, fig. 16, 1835.
HOLASTER SUBGLOBOSUS,	*Agassiz.* Prodrome, Mém. Soc. Nat. de Neuchâtel, t. i, p. 183, 1836.
SPATANGUS SUBGLOBOSUS,	*Desmoulins.* Études sur les Échinides, p. 398, 1837.
HOLASTER SUBGLOBOSUS,	*Agassiz.* Descr. des Échin. foss. de la Suisse i, p. 13, pl. ii, figs. 7—9, 1839.
— ALTUS,	*Agassiz.* Ibid., pl. iii, figs. 9—10, 1839.
— SUBGLOBOSUS,	*Römer.* Petref. der norddeutschen Kreidegebirges, p. 34, 1840.
HOLASTER SUBROTUNDUS,	*Sismonda.* Echin. Foss. del Cont. di Nizza, p. 5, 1843.
— SUBGLOBOSUS,	*Morris.* Catal. of British Fossils, p. 54, 1843.
— —	*Agassiz & Desor.* Catal. raisonné des Échinides, p. 133, 1847.
— —	*A. Gras.* Oursins Fossiles de l'Isère, p. 63, 1848.
— —	*Sorignet.* Oursins de l'Eure, p. 67, 1850.
— —	*Forbes*, in Dixon's Geol. of Sussex, p. 341, pl. xxiv, fig. 2, pl. xxix, fig. 1, 1850.
— —	*Bronn.* Lethæa Geognost., p. 204, pl. xxxi, fig. 2 *a*, *a*, 1852.
— —	*Forbes.* Mem. Geol. Surv. Decade iv, pl. vii, 1852.
— —	*Quenstedt.* Handbuch der Petref., p. 591, pl. l, fig. 14, 1852.
— —	*d'Orbigny.* Paléont. Franç., Terr. Crét., t. vi, p. 97, pl. 816, 1853.
— —	*Leymerie et Cotteau.* Catal. des Echin. Foss. des Pyrénées; Bull. Soc. Géol. de France, 2me série, t. xiii, p. 350. 1856.
— —	*Strombeck.* Glieder. des Planers, in N.-W. Deutschland; Zeitschr. der Deutschen geol. Gesellsch., vol. ix, p. 415, 1857.

Holaster subglobosus,		*Cotteau et Triger.* Éch. foss. de la Sarthe, p. 202, pl. xxxiii, figs. 7, 8, 1860.
—	—	*Lory.* Descr. du Dauphiné, pp. 350, 367, 1860.
—	—	*Dujardin et Hupe.* Suites à Buffon, Échinodermes, p. 592, 1862.
—	—	*Strombeck.* Die Kreide bei Lüneburg; Zeitsch. deutsch. Gessell., 1863.
—	—	*Cotteau.* Catal. des Échin. de l'Aube, p. 39, 1865.
—	—	*Ooster.* Synopsis des Échin. Foss. des Alpes Suisses, p. 96, 1865.
—	—	*Heer.* Die Urwelt der Schweiz, p. 205, 1865.
—	—	*Cotteau.* Échin. Foss. de l'Yonne, t. ii, p. 244, pls. lxviii, lxix, 1866.
—	—	*Renevier.* Notice sur les Alpes vaud., p. 171, 1867.
—	—	*Bucaille.* Foss. Cénomaniens de Rouen, p. 6, 1867.
—	—	*Jaccard.* Descr. Géol. du Jura vaud. et Neuchat., p. 120 1869.
—	—	*Greppin.* Descr. Géol. du Jura Vernois, p. 143, 1870.
—	—	*De Loriol.* Échinologie Helvetique, p. 330, pl. xxvi, figs. 11—14, 1873.

Diagnosis.—Test of a subglobular form, very nearly as broad and as high as it is long. The upper surface regularly convex, sometimes a little elevated at the summit; a well-marked carina rises on the middle of the single inter-ambulacrum; the under surface more or less convex; the ambitus rounded and inflated; the ambulacral summit slightly excentral in the anterior direction; posterior border narrow, obliquely truncated downwards and inwards; vent in the upper part of the area.

Dimensions.—From a number of specimens collected by the Geological Survey from different localities, the following table of comparative dimensions of six specimens, selected on account of their differences, was prepared by my colleague the late Professor Edward Forbes, to illustrate the variation in the proportions of this species.

No.	Locality.	Stratum.	Length.	Breadth.	Height.
1	Dover	Chalk-Marl	$2\frac{4}{12}$	$2\frac{5}{12}$	$1\frac{10}{12}$
2	Do.	Lower Chalk	2	2	$1\frac{3}{12}$
3	Chaldon	Chloritic Marl	$1\frac{11}{12}$	$1\frac{11}{12}$	$1\frac{4}{12}$
4	Do.	Do.	$1\frac{11}{12}$	2	$1\frac{2}{12}$
5	Do.	Do.	$1\frac{6}{12}$	$1\frac{5}{12}$	$1\frac{1}{12}$
6	Do.	Do.	$1\frac{7}{12}$	$1\frac{6}{12}$	$1\frac{2}{12}$

Varieties.—There is a curious variety of this species, in which the anteal sulcus is

deeply impressed into an almost acute furrrow. Professor Forbes found this abnormal form at the junction of the Chalk-Marl and Upper Greensand, near Abinger, in Surrey; and there is a very fine and large specimen of it in the British Museum Collection.

I have a large specimen of this Urchin in my cabinet, collected from the Pläner at Rheten, which measures in length $2\frac{6}{10}$th inches, in breadth $2\frac{6}{10}$th inches, and in height 2 inches.

Description.—This well-known Urchin of the Lower Chalk has long been familiar to collectors of Cretaceous fossils. It was very fairly figured by Leske in his 'Additamenta ad Klein.,' and has kept its place well in the list of synonyms ever since. Lamarck, however, appears to have mistaken this fossil, as he refers to Leske's figure a specimen from Grignon près Versailles, where the formation is Tertiary; so either an error in the species, or a mistake in naming the locality, has been committed.

The test is large, subcircular, or cordiform, almost as wide as it is long (fig. 1 *a*); the body is dilated and slightly grooved anteriorly, subacuminated and obliquely truncated posteriorly (fig. 1 *b*, *c*). The upper surface is convex and the ambitus uniformly inflated (fig. *c*, *d*); the base is likewise convex, except near the anteal depression for the mouth (fig. 1 *b*). The ambulacral summit is nearly central (fig. 1 *a*).

The antero-lateral ambulacra are lanceolate, apetaloid, and curve gently backwards and inwards, forming a flat Gothic arch over the anterior surface of the test (fig. 1, *a*).

The postero-lateral pair are lanceolate, apetaloid, and straight (fig. 1, *d*). The poriferous zones in the two pairs of areas are very much alike. The pores of each pair are set well apart, and connected by a furrow, but below the middle and in the wider plates they become smaller and closer. There are about forty pairs of holes in each avenue of the anterior pair, and a lesser number in the avenues of the posterior pair (fig. 1, *g*, *h*).

The single ambulacrum has a special structure. It is lodged in the anteal sulcus, which is wide and shallow. Its surface is concave and smooth, and it is linear-lanceolate. The apices of the three anterior ambulacra converge at some distance from those of the posterior pair (fig. 1, *a*), which meet near each other at the posterior portion of the apical disc. The poriferous avenues of the single ambulacrum are very narrow, the pores quite microscopic, and fewer in number than in the pairs (fig. 1, *h*).

The inter-ambulacral areas (fig. 1 *a*, *c*) are formed of large wide plates, which have their surface covered with a close-set microscopic granulation; and arising in their midst are a series of three or four irregular horizontal rows of primary tubercles. I have given a most accurate drawing of this structure in fig. 1 *g*, which shows two inter-ambulacral plates and a portion of an ambulacral area magnified three times; in fig. 1 *h* a portion of the single ambulacrum magnified three times is shown; and in fig. 1 *i* is given a view of three primary crenulated and perforated tubercles magnified, with the circles of granules surrounding the areolæ and filling in the intervening space with moderately sized granules.

The apical disc is much elongated (fig. 1 *a*, *f*); it is composed of four perforated genital plates; the right anterior plate has its surface covered with the madreporiform body, and is separated from the posterior pair by two of the perforated ocular plates, which are interposed between the anterior pair, and produce the length and narrowness of the disc; all the elements of the disc are closely soldered together, and densely covered with microscopic granulations, a few solitary tubercles only are seen in their midst.

Where the anteal sulcus curves round the ambitus (fig. 1 *e*) a depression is formed at the base (fig. 1 *b*), in which the mouth is situated; the peristome is a small, transversely oval, bilabiate aperture; the upper lip is thickened and higher than the lower, and the buccal extremities of the poriferous avenues form an irregular stellate figure around the peristome (fig. 1 *b*).

The posterior border of the test is truncated obliquely downwards and inwards (fig. 1 *c*), and in some specimens slightly hollowed into a concave channel below the vent, which occupies the upper part of the anal area (fig. 1 *d*), in a position about half the height of the test. The periprocte is vertically of an elliptical figure (fig. 1 *d*), and its upper angle forms the termination of the dorsal carina which extends backwards from the disc to the border.

Affinities and Differences.—This Urchin is so well characterised by its specific features that it is not easily mistaken for any other. *Hol. cor-avium*, Lamk., has been ascertained by d'Orbigny's inspection of the type in the museum to be a siliceous mould of *Hol. subglobosus*; and *Hol. nasutus*, labelled by M. Agassiz in the museum, is only a specimen of *Hol. subglobosus* deformed by pressure.

Locality and Stratigraphical Position.—This Urchin abounds in the bed of Chalk with green grains intervening between the Upper Greensand and Chalk-Marl. It is found also plentifully in the Chalk-Marl itself and more rarely in the Lower Chalk. I have had many fine specimens from the Chloritic Marl near Chard, and from the Chalk-Marl near Lewes, in Sussex. The Chalk-Marl of Wiltshire and of Dorsetshire has yielded many specimens. This species, says Forbes, has not been found in Ireland.

Foreign Localities.—It is found at the Mountain Sainte-Catherine, near Rouen, Fécamp, and Havre, at Saint-Parre and Laubresel, near Troyes, Aube; with *Acanthoceras Rotomagense*, Brong., at Pourrain, and Seigneley, Yonne; Sancerre, Cher; Cassis, Bouches-du-Rhône; Bidart, near Biarritz, Basses-Pyrénées; Villers-sur-Mer, Calvados; Trinité, near Nice. In Switzerland, in the 'Etage Cénomanien,' Monsieur De Loriol records it from Sainte-Croix, Vaud.; Cheville, Valais; Ried, near Bienne, Berne; Summit of Sentis, Ebenalp, Sentis; Seealp, Appenzell, Yberg-Sil, Schwytz; Lac Saint-Point, Jura. In Germany, Goldfuss records it from Quedlinburg, Prussia; Neuwallmoden and Langelsheim, Brunswick.

HOLASTER TRECENSIS, *Leymerie*. Pl. LXXIV, fig. 2, *a*—*e*.

HOLASTER TRECENSIS,	*Leymerie*.	Mém. de la Soc. géol., p. 2, pl. ii, fig. 1, 1842.
— —	*Agassiz*.	Catal. raisonné, p. 134, 1847.
— PILLULA var. MAXIMA,	*Agassiz* and *Desor*.	Ibid., p. 135, 1847.
— TRECENSIS,	*d'Orbigny*.	Prodrome 2, p. 269, No. 1161, 1847.
— —	—	Pal. Franç., Ter. Crétacés, vol. vi, p. 101, pl. 847, 1853.

Diagnosis.—Test oblong, cordiform; upper surface very much elevated, rounded, and grooved before, tapering gently to a narrow truncation behind. Ambulacral summit nearly central; under surface very flat; mouth near the border. Vent in a small marginal anal area near the angle; upper surface covered with large tubercles, arranged without much regularity upon both areas.

Dimensions.—Antero-posterior diameter two inches and four tenths; transverse diameter two inches and four tenths; height one inch and five tenths.

Description.—The test is oval and cordiform, much inflated, and nearly as broad as long; enlarged and sinuous before, accuminated behind. The upper surface is much elevated and very convex, the outlines antero-posteriorly, as well as laterally, describing regular curves (fig. 2 *c*, *d*). The ambulacral summit is nearly central (fig. 2 *a*), where we find the apical disc, which is small, and shows four perforated genital plates. The central portions of the inter-ambulacra are rather prominent, which imparts an angular appearance to the ambitus (fig. 2 *d*). The base is very flat, with the exception of a slight prominence in the middle of the plastron, where we observe seven alternate elevations, with a connective zigzag ridge between (fig. 2 *b*). The anterior portion near the anteal sulcus is slightly depressed (fig. 2 *b*), where we find the mouth-opening, which is large, and transversely oval. The peristome is bilabiate; the anterior lip is depressed and convex, and the posterior elevated and prominent. The vent occupies the posterior border, and opens near the base; it is situated in a small triangular anal area, slightly excavated out of the border (fig. 2 *e*). The periprocte is longitudinally oval, placed under an angular projection in the median line, with two lateral ridges to divide the area from the ambital circumference (fig. 2 *e*).

The ambulacral areas are very feebly defined in this Urchin; the anterior single area is lodged in the sulcus; its poriferous zones are only slightly visible near the summit. The antero-lateral and postero-lateral pairs are narrowly lanceolate. The anterior pair curve slightly forwards, and the posterior pair are straight (fig. 2 *a*). The poriferous zones are formed of transverse oblong pores arranged in pairs, and the anterior is smaller than the posterior row; they extend half-way over the upper surface and sides, and disappear above the ambitus (fig. 2 *c*, *d*).

The tubercles are of two kinds; small tubercles, which are seen in the ambulacral

areas and on other parts of the test, and large tubercles, developed upon the inter-ambulacral plates without much order or regularity, and varying much in number in different specimens. These tubercles are perforated at the summit, and raised upon bosses with crenulated rims. The specimen I have figured shows this tubercular structure to perfection, but the majority of specimens want the profusion of large tubercles seen on the figured shell (Pl. LXXIV, fig. 2). Besides the tubercles just described, the surface of the plates is covered with microscopic granules which form circles around the base of the tubercles and crowd the spaces between them with a close-set granulation. It is only in well-preserved specimens, however, that this structure can be observed, and then only by the assistance of a lens.

Affinities and Differences.—This fine Urchin was well figured by the late Prof. Leymerie in 1842,[1] and afterwards by d'Orbigny in 1853.[2] I had been fortunate in procuring a very fine example of this Holaster from the Grey Chalk of Folkestone, and I desired my late friend Mr. Bone to make most accurate figures of it, which he has done, and given five beautiful drawings of the same in Plate LXXIV, fig. 2 *a*—*e*.

At first sight one naturally concludes that *Hol. Trecensis*, Ley., is a well-defined form, and fully entitled to specific rank, but a closer examination of the test, and a comparison of it with other fossils considered to be *Hol. carinatus*, weaken our faith in this belief. Characters at first sight thought to be specific appear to be evanescent. The size and number of the tubercles on the upper surface of *Hol. Trecensis*, for instance, are not constant, seeing that in some specimens they dwindle away, and in others almost disappear. Finally, the close identity of *Hol. Trecensis* with *Hol. carinatus*, from being a doubt, becomes a certainty. Now arises the next question, in what does *Hol. carinatus* differ from *Hol. lævis?* Failing to discover the specific differences which many eminent palæontologists have thought they saw in these different forms, we have at length arrived at the conclusion that my learned friend Mons. De Loriol came to, after a patient and exhaustive study of *Hol. lævis*, namely, that these three forms—*Hol. carinatus*, *Hol. Trecensis*, and *Hol. lævis*—are only varieties more or less defined of *Hol. lævis*, De Luc.

Locality and Stratigraphical Position.—The fine specimen figured in Pl. LXXIV, fig. 2, was collected from the Grey Chalk, near Folkestone, and I have several other large specimens from the Lower Chalk of Wiltshire and from the Medial Chalk, Swaffham, Norfolk.

Foreign localities.—Prof. Leymerie found his type specimen at Saint-Parre, near Troyes, Aube; it has been collected likewise at Mont Saint-Catherine, Rouen, Seine-Inférieure, with *Acanthoceras Rhotomagense;* and from the Chloritic Chalk in the environs of Saint-Croix, Vaud, Switzerland.

[1] 'Mém. de la Soc. géol. de France,' p. 5, pl. ii, fig. 1, 1842.

[2] 'Paléontologie Française, Ter. Crétacés,' tom. vi, pl. 847, 1853.

THE

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MONOGRAPH

ON THE

BRITISH FOSSIL

ECHINODERMATA

FROM

THE CRETACEOUS FORMATIONS.

BY

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Smithsonian Institution

VOLUME FIRST.

PART TENTH.

CONCLUSION.

PAGES i—xviii, 325—371; PLATES LXXVI—LXXX.
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CARDIASTER PILLULA, *Lamarck*. Pl. LXXI, figs. 1—3.

ANANCHYTES PILLULA,	*Lamarck*. Animaux Sans Verteb., tom. iii, p. 27, No. 11, 1816.
SPATANGUS PRUNELLA,	*Mantell*. Geology of Sussex, pl. xvii, figs. 22, 23, p. 193, 1822.
ANANCHYTES PILLULA,	*Deslongchamps*. Encycloped. Method., tom. ii, p. 64, 1824.
NUCLEOLITES CORAVIUM,	*Cutullo*. Saggio de Zool., p. 226, pl. 2, fig. *e*, 1827.
SPATANGUS PILLULA,	*Desmoulins*. Études sur les Échinides, p. 406, No. 50, 1837.
ANANCHYTES ANALIS,	*Roemer*. Norddeutsch Kreide, pl. 6, fig. 18, p. 35, 1840.
HOLASTER PILLULA,	*Agassiz and Desor*. Catal. raisonné, An. Sc. Nat., tom. viii, p. 29, 1847.
ANANCHYTES (HOLASTER) PILULA,	*Forbes*. Mem. Geol. Surv., decade iv, pl. viii, 1852.
CARDIASTER PILULA,	*d'Orbigny*. Paléontol. Française Terr. Crétacés, tom. vi, p. 126, pl. 824, 1853.

Diagnosis.—Test oblong, lofty, always more or less elevated ; sides tumid ; anterior border round and flattened; posterior accuminated and truncated; base flatly convex with sharp angulated sides, mouth near the anterior border; vent elevated in the middle of the posterior border; upper surface highly arched, with a carina passing from the disc to the vent; apical disc narrow, elongated, and nearly central.

Dimensions.—Height, $\frac{11}{20}$ of an inch; antero-posterior diameter, $\frac{7}{10}$ of an inch; transverse diameter, $\frac{5}{10}$ of an inch.

The proportional dimensions of this Urchin vary considerably, a fact which may best be illustrated by the measurement of six specimens of different bulk, in inches and parts of an inch, as shown in the following table:

TEST.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Height	$0\frac{8}{10}$	$0\frac{5}{8}$	$0\frac{1}{2}$	$0\frac{1}{2}$	$0\frac{4}{10}$	$0\frac{11}{12}$
Antero-posterior diameter.....	1	$0\frac{8}{10}$	$0\frac{7}{10}$	$0\frac{8}{10}$	$0\frac{16}{10}$	$0\frac{11}{12}$
Lateral diameter.....	$0\frac{8}{10}$	$0\frac{7}{10}$	$0\frac{7}{10}$	$0\frac{6}{10}$	$0\frac{6}{10}$	$0\frac{9}{12}$
Vent above margin	$0\frac{3}{10}$	$0\frac{3}{10}$	$0\frac{2}{12}$	$0\frac{2}{12}$	$0\frac{2}{12}$	$0\frac{2}{12}$

Description.—Test oblong, always more or less elevated, tumid above, inflated at the sides and flattened at the base; the anterior border depressed, with the central sulcus feebly developed and the posterior border accuminated and abruptly truncated.

The anteal and antero-lateral ambulacra are short, lanceolate and nearly vertical; the postero-lateral long, ascending obliquely forward, and conjointly forming an arch which encloses the posterior truncated border with the circular vent about half way up the total height of the test (see Table). The plates of the ambulacra are large and broad, each equal to as much or rather more than half the height of an interambulacral plate. In a rather large example of this species there are seventeen dorsal plates in each vertical row of the anteal ambulacrum, about fourteen and thirteen respectively in the rows of each lateral ambulacrum, and seven in each vertical row of each lateral inter-ambulacrum (Pl. LXXI, fig. 1 *c*). These plates all bear minute scattered primary tubercles, with myriads of interspersed granules (Pl. LXXI, fig. 1 *b*).

The upper surface is convex, and more or less arched throughout; the highest point is in the anterior third, from whence it gently declines towards the posterior border (figs. 1 *c* and 3 *a*). The apical disc is closely wedged in between the other plates of the test, and often distinguished with difficulty; it is situated about the centre of the test, rather nearer the anterior border, and is narrow and extremely elongated (fig. 1 *e*); the ovarial plates being placed in line behind each other, and four are perforated. The ocular plates are very small, and can only be discerned by the aid of a magnifying lens. The madreporiform body is very small and indistinct. In some flint casts the four ovarial holes are seen, and the pairs of pores in the poriferous zones very well shown (fig. 2); their courses are much better traced out in such moulds than in specimens with the test preserved.

From the posterior side of the apical disc to the upper margin of the vent a carina more or less acute is developed (fig. 1 *a*), this ends in a beak-shaped process which overhangs the anal aperture.

The under surface is slightly convex, and a little angular along the median line, without any concavity around the mouth, which occupies a position near the anterior extremity, about one fourth of the length of the test from the margin, which in the region of the anteal ambulacrum is slightly sinuous (fig. 1 *b*). The oral aperture is roundish or ovate, the fore lip is depressed, and the hinder lip turned and elevated, but not overlapping.

The vent of an oval form occupies an elevated position in the posterior border (figs. 1 *d* and 3 *a*). This aperture was defended by a series of small plates, eight polygonal calcareous pieces forming the outer, and ten smaller pieces the inner circle of the lid, so that the periprocte was entirely closed with the exception of a small central aperture for the passage of the rectum. I have given an accurate drawing of these anal ossicles *in sitû* for shutting up the periprocte in fig. 3 *b*.

This beautiful little Urchin likewise possesses a band of minute granules towards the side margins of the ambitus, forming there a fasciole like a *Cardiaster;* for this reason it is now removed from the genus *Ananchytes,* where it was placed, but in which no fascioles exist, into the group which possesses this granular band along the margin of the

cheeks. In other respects its form and structure has many affinities with *Echinocorys* on the one side and *Holaster* on the other, between which it forms a connecting link.

Locality and Stratigraphical Position.—It is found in the upper chalk of Kent, Sussex, and other English counties.

In France it is collected from the upper chalk at Meudon, near Paris; Dens, Poigny, Yonne; Beauvais, Oise; Saintes, Charente-Inférieure.

In North Germany it has been found at Peine, at Yseburg, near Hanover.

History.—This Urchin was first described by Lamarck as *Ananchytes pillula*, and afterwards by Deslongchamps under the same name. Desmoulins removed it into the genus *Spatangus*, Roemer described and figured it as *Ananchytes analis;* Agassiz and Desor removed it into the genus *Holaster*. Forbes called it *Ananchytes* (*Holaster*) *pillula*, and described and figured it in his Memoirs of the Geological Survey in much detail and with great accuracy; and finally D'Orbigny, having ascertained the presence of the fasciole which extends along the margin and under the posterior border, removed it into the genus *Cardiaster*, among its marginal fasciolated congeners.

Genus—Echinocorys, *Breynius*, 1732.

Ananchytes, *Lamarck*, 1801.

Form of the test more or less oval; upper surface much elevated, helmet-shaped, convex, conoidal, or rounded; under surface flat.

Ambulacral summit central, the poriferous zones occupy the middle of the ambulacral plates; the single ambulacrum similar in structure to the antero- and postero-lateral pairs. The pores round or elongated, alike identical in structure, disposed in single pairs, set obliquely widely apart in the middle of the ambulacral plates, and forming two rows in each area, which radiate from the summit and diverge towards the circumference.

Apical disc elongated, formed of four ovarial and five ocular plates. The two pairs of ovarial plates are separated by a pair of oculars.

Under surface very flat. Mouth-opening near the anterior border transversely oval; peristome bilabiate, situated in a depression, and surrounded by a stellate arrangement of primary tubercles, which diverge from the circumference of the peristome.

Vent marginal or infra-marginal; periprocte small and oval in a vertical direction.

Surface of the plates covered with small primary tubercles; those at the base are larger and more developed, some are raised upon bosses with crenulations, and all are perforated at the summit.

The Echinocorys resemble the Holasters, but are distinguished from them in having the single ambulacrum precisely similar to the others, and by the absence of the anteal sulcus. The position of the periprocte is likewise entirely marginal or infra-marginal.

This genus was well established by Breynius, in 1732, and illustrated with good figures; it is to be regretted that Lamarck, in 1801, suppressed the name *Echinocorys*, and proposed, without any reason for it, that of *Ananchytes*, now so well known to all geologists; still, in justice to Breynius, I am under the necessity of restoring his name in order to carry out the principle which has guided me in the nomenclature I have adopted throughout this work.

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CAP-STONES, oval form, Plot. Nat. Hist. of Oxfordshire, p. 92, tab. ii, 1677.
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— SCUTATUS, *Leske*. Apud Klein Dispos. Echinod., p. 175, pls. xv, A, B, 1778.
— OVATUS, *Leske*. Ibid., p. 178, pl. xliii, fig. 1, 1778.
— MINOR, *Leske*. Ibid., p. 183, pl. xvi, C, D; pl. xvii, fig. *a*, *b*, 1778.
— PUSTULOSUS, *Leske*. Ibid, p. 180, pl. xvi, figs. A, B, 1778.
ECHINUS SCUTATUS, *Gmelin*. Systema Naturæ, t. i, p. 3184, 1789.
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— OVATUS, *Lamarck*. An. sans Vert., t. i, p. 348, 1801.
ECHINOCORYS SCUTATUS, *Parkinson*. Organic Remains, vol. iii, p. 21, pl. ii, fig. 4, 1812.
ANANCHYTES OVATA, *Lamarck*. Animaux sans Vertèbres, vol. iii, p. 25, No. 1, 1816.
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— GIBBA, *Lamarck*. Ibid., No. 3.
— PUSTULOSA, *Lamarck*. Ibid., No. 4.
— SEMIGLOBUS, *Lamarck*. Ibid., No. 10.
ANANCHITRES OVATUS, *Defrance*. Dic. Sc. Nat., vol. ii, Suppl., p. 40, 1816.
ANANCHITES CARINATUS, *Defrance*. Ibid., p. 41.
ECHINITES SCUTATUS, major et minor, *Schlotheim*. Petrefaktenkunde, p. 309, 1820.
ANANCHYTES OVATA, *Brongniart* (Cuvier). Géol. Environs de Paris, p. 390, pl. M, fig. 7, A, B, D, 1822.
— HEMISPHÆRICA, *Brongniart*. Ibid., fig. 8, A, B, C, 1822.
ECHINOCORYS SCUTATUS, *Mantell*. Geology of Sussex, p. 191, 1822.
ANANCHYTES OVATA, *Deslongchamps*. Mollusques et Zoophytes, t. ii, p. 61, 1824.
— STRIATA, *Deslongchamps*. Ibid., p. 62, No. 2.
— GIBBA, *Deslongchamps*. Ibid., p. 62, No. 3.

ANANCHYTES PUSTULOSA,		*Deslongchamps.* Ibid., No. 4.
—	SEMIGLOBUS,	*Deslongchamps.* Ibid., p. 63, No. 5.
—	OVATUS,	*Goldfuss.* Petrefact. Germaniæ, vol. i, p. 145, pl. xliv, fig. 1, 1826.
—	CONOIDEUS,	*Goldfuss.* Petrefact. Germaniæ, vol. i, p. 145, pl. xliv, fig. 2, 1826.
—	STRIATUS,	*Goldfuss.* Ibid., fig. 3.
ECHINO-CORYS OVATUS,		*Mantell.* Geol. Transact., vol. iii, p. 205, 1829.
ANANCHYTES OVATUS,		*Blainville.* Zoophytes, Dict. Sc. Nat., t. lx, p. 187, 1830.
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—	PUSTULOSUS,	*Blainville.* Ibid.
—	SEMIGLOBUS,	*Blainville.* Ibid.
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—	GIBBA,	*Agassiz.* Monogr. Radiaires; Mém. Soc. des Sc. Nat. de Neuchâtel, vol. i, p. 183, 1835.
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—	GIBBA,	*Agassiz.* Ibid.
—	PUSTULOSA,	*Agassiz.* Ibid.
—	STRIATA,	*Grateloup.* Act. Soc. Lin. Bord., t. viii., Mém. Oursins Foss., p. 60, 1836.
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—	SEMIGLOBUS,	*Grateloup.* Ibid., p. 62.
—	HEMISPHÆRICA,	*Grateloup.* Ibid., p. 62.
—	CONOIDEA,	*Grateloup.* Ibid., p. 62.
—	PUSTULOSA,	*Grateloup.* Ibid., p. 63.
—	OVATA,	*Des Moulins.* Études sur les Échin., p. 369, No. 1, 1837.
—	CONOIDEA,	*Des Moulins.* Ibid., p. 370, No. 2.
—	STRIATA,	*Des Moulins.* Ibid., No. 3.
—	GIBBA,	*Des Moulins.* Ibid., p. 372, No. 4.
—	PUSTULOSA,	*Des Moulins.* Ibid., No. 5.
—	HEMISPHÆRICA,	*Des Moulins.* Ibid., p. 374, No. 6.
—	SEMIGLOBUS,	*Des Moulins.* Ibid., No. 8.
—	OVATA,	*Agassiz.* Échin. de la Suisse, p. 30, pl. iv, figs. 4—6, 1839.
—	STRIATA,	*Agassiz.* Catal. Syst. Éctyp. Echin. Foss. Mus. Neoc., p. 2, 1840.
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—	OVATA,	*Dujardin.* In Lamarck, Anim. sans. Vert., 2 ed., t. iii, p. 316, 1840.
—	STRIATA,	*Dujardin.* Ibid., No. 2.
—	GIBBA,	*Dujardin.* Ibid., No. 3.
—	PUSTULOSA,	*Dujardin.* Ibid., No. 4.
—	SEMIGLOBUS,	*Dujardin.* Ibid., No. 10.
—	CONOIDEA,	*Dujardin.* Ibid., No. 13.
—	HEMISPHÆRICA,	*Dujardin.* Ibid., No. 14.
—	OVATA,	*Roemer.* Norddeutschen Kreidegebirges, p. 35, 1840.
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— CONICA, *Agassiz* et *Desor.* Ibid.
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— STRIATA, *d'Orbigny.* Ibid., No. 1149.
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— CONICA, *d'Orbigny.* Ibid., N. 1154.
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— GIBBA, *Sorignet.* Ibid., No. 90.
— EUDESII, *Sorignet.* Ibid., No. 91.
— STRIATA, *Sorignet.* Ibid., No. 92.
— GRAVESII, *Sorignet.* Ibid., No. 93.
— CONICA, *Sorignet.* Ibid., No. 94.
— SEMIGLOBUS, *Sorignet.* Ibid., No. 95.
— OVATA, *Leymerie.* Mém. Soc. Geol. France, 2 ser., t. iv, p. 201, pl. xi, fig. 5, 1852.
— — *Quenstedt.* Handbuch Petrefak., p. 591, pl. i, fig. 19, 1852.
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— OVATA, *Bronn.* Lethæa Geognost. Kreidegebirge, p. 206, 1852.
ECHINOCORYS VULGARIS, *d'Orbigny.* Pal. Française Ter. Crétace, t. vi, p. 62, pls. 805, 806, 1853.
— PAPILLOSUS, *d'Orbigny.* Pro part., ibid., p. 69.
ANANCHYTES OVATUS, *Morris.* Catal. of British Fossils, p. 71, 1854.
ECHINOCORYS VULGARIS, *Leymerie* and *Cotteau.* Catal. des Echin. des Pyrenées, Bull. Soc. Geol. France, t. xiii, p. 331, 1856.
ANANCHYTES OVATA, *Desor.* Synops. des Echinides Foss., p, 330, 1857.
— — *Hébert.* Craie de Meudon, Bull. Soc. Géol. de France, 2 ser., t. xvi, p. 145, 1858.
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Ananchytes conica,	*Coquand.* Ibid.
Echinocorys vulgaris,	*Cotteau.* Ech. d'Espagne Bull. Soc. Géol. France, t. xvii, p. 373, 1860.
Ananchytes ovatus,	*Strombeck.* Uber die Kreide bei Luneburg, Zeitschrift der Deutschen Geol. Gesellschaft, vol. xv, p. 134, 1863.
Echinocorys vulgaris,	*Cotteau.* Échinides Foss. des Pyrenées, p. 45, 1863.
— —	*Cotteau.* Catal. des Échin. Foss. de l'Aube, p. 41, 1865.
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Ananchitis ovata,	*Ooster.* Synop. des Échinod. foss. des Alpes Suisses, p. 91, 1865.
— —	*Heer.* Die Urwelt der Schweiz, p. 205, vign., fig. 117, 1865.
Ananchites conica,	*Favre.* Rec. Géol. Savoie, t. iii, p. 494, 1867.
Echinocorys gibba,	*Schlönbach.* Grünsandes von Rothenfelde, p. 821, 1869.
— vulgaris,	*De Loriol.* Échinides Crétacés de la Suisse, p. 308, 1873.

Diagnosis.—Test large, rounded anteriorly, with a circular, ovate, or suborbicular ambitus; upper surface much elevated with turned sides; under surface flat; mouth sunk in a deep depression; vent small and infra-marginal. My late colleague, Professor Edward Forbes, admitted the following varieties.

Forma α.—*Alta, hemisphærica, ambitu ovato.*

Ananchytes ovata and conoidea, *Auctorum.*

Forma β.—*Alta, elongata, superne depressa, ambitu ovato,*

Ananchytes striata, *Auct.?* ovata, pars.

Forma γ.—*Alta, superne depressa, ambitu orbiculari.*

Ananchytes gibba, *Agassiz.*

Forma δ.—*Sub-globularis.*

Forma ε.—*Alta, conica.*

Ananchytes conica, *Agassiz,* Ananchytes pyramidata, *Portlock.*

Dimensions.—Height, 55 millimètres; transverse diameter, 62 millimètres; antero-posterior diameter 75 millimètres. Monsieur Cotteau has given the comparative dimensions of the three varieties which he admits of this species.

Var. gibba.—Height, 69 millimètres; transverse diameter, 68 millimètres; antero-posterior diameter, 86 millimètres.

Var. conoidea.—Height, 77 millimètres; transverse diameter, 68 millimètres; antero-posterior diameter, 79 millimètres.

Var. conica (young form).—Height, 37 millimètres; transverse diameter, 33 millimètres; antero-posterior diameter, 43 millimètres.

Description.—This fine large Urchin, so very characteristic of the Upper Cretaceous formation, is rounded before and slightly contracted behind the upper surface, is much elevated, inflated, and more or less regularly convex. Sometimes elevated and conical, always slightly carinated in the posterior region. The inferior surface is flat, more or less rounded at the border, and deeply depressed around the mouth, presenting, in the median plane, an elevation which corresponds to the single interambulacral area. The ambulacral summit is nearly central. The ambulacra separated without being disjoined, are entirely similar to one another, and visible from the summit to the mouth; the poriferous zones are formed of round holes placed obliquely in pairs; the holes are perforated in the middle of the ambulacral plates (fig. 1 *f*), a form of structure which is altogether different from other congeneric groups. The pairs of pores are set closely together in the upper part of the zones, more widely apart on the sides, and remote from each other about the ambitus; near the peristome the pores again approximate, where they are surrounded by a stellate arrangement of the tubercles around the oral aperture (fig. 1 *b* and *c*).

The ambulacral plates are small and narrow in the upper part, and become large and broad in the lower and middle portions of the areas, and they are all perforated near their centres.

The tubercles developed on the upper surface of the plates of both areas are small and nearly equal in size, and those found at the base are large and prominent. In well-preserved specimens they are seen to be scrobiculated, crenulated, and perforated; they are small and irregularly placed on the upper surface (fig. 1 *a*, *f*), larger and more regularly arranged near the ambitus, and in the middle of the under surface they are much larger and more closely set together, and raised on bosses with crenulated summits (fig. 1 *g*, *h*). The intermediate granulation on the surface of the plates is quite microscopic, abundant, and homogeneous, forming regular circles around the tubercles and filling up all the intermediate spaces with minute granules (fig. 1 *f*).

The apical disc (fig. 1 *d*) is elongated; it is formed of four large perforated ovarial plates and five large oculars. Of the two anterior ovarials the right one is the largest, and supports the madreporiform body. The two anterior oculars are larger than the other three, and the orbits in all are marginal; all the discal elements are closely soldered together and covered with a fine granulation. On flint moulds (fig. 11) the position of the central portion of the apical disc is marked by a space included within an oblong groove. This groove is caused by the impressions of the walls of a solid tube-like body projecting from the inner surface of the apical disc into the cavity of the test and directed backwards. This organ appears to have been the sand canal, and was connected with the madreporiform body, as shown in fig. 11. On flint moulds the pores of the avenues are strongly projecting (fig. 10), where we notice the basal position of the poriferous zones.

The small mouth-opening is situated in a deep depression near the anterior border. At the termination of the median elevation the peristome is transversely oval, with a

slightly prominent under lip, and there radiates from its circumference a stellate disposition of large tubercles (fig. 1 *b*, *e*), which highly ornament the oral opening. The small vent opens at the infra-marginal region near the termination of the posterior carina and behind an elevation and thickening of the test, which may be described as the anal area; the periprocte is oval in the longitudinal direction (fig. *a*, *b*).

Affinities and Differences.—The abundance of this species in the Upper Chalk beds causes many variations of form to be displayed which have been described and figured by collectors as distinct species; I shall mention some of the most remarkable. The upper surface is often inflated and gibbous, very regularly convex, angular, and a little contracted towards the base; this is the *Ananchytes gibba*, Lamarck, the *Ananchytes striatus* (var. *subglobosus*), Goldfuss ('Petref. Germaniæ,' pl. xliv, fig. 3). Sometimes this variety has the body more elongated, the upper surface less gibbous and marked in the posterior region, with the carina more developed, the base always angular at the circumference and slightly contracted; this is the *Echinocorys scutatus*, Leske, and *Ananchytes striata*, Lamarck. Sometimes the upper surface, whilst preserving a gibbous and convex aspect, is elevated and conoidal; this is the *Ananchytes conoideus*, Goldfuss (pl. xliv, fig. 2), the variety γ of Professor Forbes. When the ambitus is considerably contracted, and the upper surface inflated, the shell has a remarkable subspherical appearance; it then forms the *Ananchytes Gravesii*, Desor. This variety sometimes attains a large size, then the upper surface loses its gibbous aspect and becomes altogether conical, it is then the *Echinocorys pustulosus*, Leske, and the *Ananchytes conica*, Agassiz.

All these varieties, and several others which are mentioned in the works of different authors, such as *Ananchytes carinatus*, Defrance, *A. pyramidatus*, Port., *A. semiglobus*, Lamk., *A. crassissima*, Agass., *A. Eudesii*, Sorignet, &c., appear to be modifications of the same type, and merely varieties of the fine formed shell I have figured as *Echinocorys vulgaris*, Breynius.

On this subject Professor Forbes observes,[1] "To this last view I feel compelled to assent, for, however distinct the forms termed *ovata*, *gibba*, *striata*, *semiglobus*, *conica*, &c., may seem when selected and contrasted in the cabinet, every one of them is linked with the others by the most delicate shades of gradation. Neither in degree of elevation, rotundity, flatness of base or curve of back, smoothness or roughness, can I find any constant character. Scarcely two individuals out of more than a hundred examples now before me exhibit the same proportions."

The *Echinocorytes ovatus*, Leske (Pl. LXXVII, fig. 9), is a well-marked form found in the Chalk of Meudon. When compared with the *Echinocorys vulgaris* (Pl. LXXVII, fig. 1 *a*, *b*, *c*), its general outline is seen to be more ovoid, elongated, and more sensibly rostrated posteriorly; its upper surface is thicker and more inflated anteriorly; the ambitus is rounder, less angular, and the under surface more depressed around the mouth-opening; the ambulacra are larger as they approach the summit, and form a less acute angle; the

[1] 'Memoirs of the Geological Survey; British Organic Remains,' decade iv, pl. vi, p. 4, 1852.

vent is, in general, more infra-marginal, and the single inter-ambulacrum has well-marked eminences. Now, all these points of difference, so well marked in some specimens, are not constant, since they gradually disappear in some and vanish away entirely in others.

Locality and Stratigraphical Range.—The variety *Echinocorys ovatus*, Leske, is a characteristic fossil of the White Chalk, and found in abundance in the south-east of England, especially in the Counties of Kent, Surrey, Sussex, and the Isle of Wight. It occurs in both the middle and lower parts of the series. The varieties *striata*, Lamk., and *subglobularis* prevail in the Lower Chalk, so that varieties in point of form may have a certain value in stratigraphical distribution, such as is apparent in certain species of *Micraster*.

In Ireland, General Portlock found the variety *E. ovatus* was characteristic of the Lower Chalk beds, whilst in England its horizon is the Upper Chalk.

ADDENDA.

MICRASTER COR-TESTUDINARIUM, *Goldfuss*. Pl. LXXVI, fig. 1 *a—f*, and fig. 2 *a—e*.

SPATANGUS COR-TESTUDINARIUM,	*Goldfuss*.	Petref. German., p. 156, pl. xlviii, fig. 5, 1826.
MICRASTER	—	*Agassiz*. Prod. Monog. des radiaires; Mém. Soc. des Sc. Nat. de Neuchâtel, t. i, p. 184, 1835.
—	—	*Roemer*. Nord-deutschen Kreidgebirges, p. 33, 1840.
—	—	*Morris*. Catal. of British Fossils, p. 54, 1843.
—	—	*Hébert*. Foss. de la Craie du Meudon Mém. Soc. Géol. de France, 2 sér., t. v, pl. xxix, fig. 18, 1855.
—	—	*Evans*. Proc. Geol. Assoc., vol. v, No. 4, pl. ii, 1877.

Diagnosis.—Test cordiform, greatest width at the junction of the anterior with the middle third of the ambitus, posterior two-thirds tapering to a very narrow posterior border. Upper surface convex, more or less elevated, anterior half obliquely declining towards the anteal sulcus, posterior half often developing a prominent central ridge extending from the disc to the periprocte; summit central; surface of the plates covered with small tubercles. Under surface convex; plates covered with large tubercles; mouth-opening at a distance from the border, near the junction of the first with the second fourth of the antero-posterior diameter of the base. Peristome transversely oval, with a thick, projecting lower lip.

Dimensions.—Height one inch and a half; length two inches and one tenth; width two inches and one tenth.

Description.—It is difficult to unravel the synonymy of this species, seeing that it has been confused by some with *Micraster brevis*, and by others with *Epiaster gibbus*; so that unless we had the specimens referred to for special examination and comparison, it would be impossible to determine the species indicated in some published lists. I have limited, therefore, my synonyms to the few examples I happen to know.

Goldfuss figured, as the type of his species, a large globular variety, but did not at the same time indicate that it was an exceptional example, and for this reason English geologists were long doubtful whether our Chalk contained the German *Micraster cor-testudinarium*, Goldf. In consequence of considerable importance having lately been attached to this species by Continental geologists in their classification of the Cretaceous

formation, and good examples of the common type-forms of the Urchin having been sent from France and Belgium for comparison with English specimens, it soon became evident that we had an abundance of the form in our Cretaceous strata, and that with us, as on the Continent, the species characterised a well-marked zone in the Cretaceous formation. I am indebted to Caleb Evans, Esq., F.G.S., for a series of good specimens from different Sussex and Surrey railway-cuttings, to illustrate the stratigraphical distribution of this species; and in order that I might figure the ordinary forms of the true German types of *Mic. cor-testudinarium*, I applied to my friend, Herr C. Struckmann, of Hanover, a distinguished palæontologist, to send me good types of this Echinide to enable me to give figures of it for reference; and I beg to thank my friend for four beautiful examples, one of which I have figured in Pl. LXXVI, fig. 1 *a—f*, for comparison with the British forms obtained from sections on the Surrey and Sussex Railway, near Purley and Kenley, villages between Croydon and Caterham, and likewise from Dover.

It is a very difficult matter to describe the points in which *Micraster cor-anguinum* differs from *Micraster cor-testudinarium*, *Micraster breviporus*, and *Micraster cor-bovis*, inasmuch as these four forms blend into each other by intermediate shapes, which may be obtained from a number of specimens of each group; and yet typical examples of the four forms when placed alongside each other, seem sufficiently distinct to the eye of the observer to justify the separation of the species.

In *Micraster cor-testudinarium*, the test, in general, is flattened on the upper surface, and the ambitus from the anterior third backwards tapers much towards the posterior border, so that the shell has an elongated pyriform shape not much inflated at the sides. In some specimens with an elevated upper surface the test assumes a conoidal outline, as seen in Pl. LXXVI, fig. 1 *b*. In some a prominent ridge extends from the apical disc to the periprocte (fig. 1 *a* and fig. 2 *a*), which is absent in others; in all, the anteal sulcus is shallow and only slightly grooves the anterior border (fig. 1 *a* and fig. 2 *a*); the apical disc is likewise nearly always central and lies in a depression at the summit (fig. 1 *a*, fig. 2 *a*).

The pairs of petaloid ambulacra are of unequal length, the antero-lateral pair is one third longer than the postero-lateral; they are not flexed, and extend straight and obliquely outwards at an angle of 40° (fig. 1 *a* and fig. 2 *a*); the poriferous zones have very small holes arranged in pairs, with a double row of granules extending vertically between the two rows, and forming, in the petaloid portion of the area, a well-marked boundary to the central suture, which is very much depressed. The non-petaloid portion of the area is formed of rhomboidal plates which are articulated with the large interambulacral series (fig. 1 *d*); the single ambulacrum filling the anteal sulcus is narrow, the pores are placed closer together, and the plates are flatter, and have an imbricated appearance in many specimens (fig. 1 *a*, fig. 2 *a*). The non-petaloid portion consists of longer rhomboidal plates with the pores situated widely apart and visible down to the central sulcus (fig. 1 *d*).

The interambulacral areas are wide, and formed of large plates, eight, ten, or twelve in each column, according to the age of the Urchin. They are largest at the base and diminish in size on the sides and upper surface. The plates are covered with several (four to six) irregular rows of tubercles, nearly uniform in size, and from 20 to 30 on each (fig. 1 *d*); the surface of the plates is covered with a microscopic granulation, which forms circles around the tubercles. At the base, the tubercles are much larger, especially about the cheeks and anteal sulcus, and on the plastron they are closely clustered together; they are encircled by smooth areolæ, each surrounded by a ring of granules (fig. 1 *f*).

The subanal fasciole is very distinctly visible in all the specimens that have passed through my hands.

The apical disc is a small body set in a central depression, and composed of four perforated ovarial, and five perforated ocular plates, all closely welded together, the right antero-lateral ovarial having a small madreporiform body on its surface (fig. 2 *d*).

The posterior border is narrow and truncated obliquely downwards and inwards. The vent occupies the upper part of this region, and the oval periprocte opens beneath the termination of the central ridge on the upper surface (fig. *c*).

The base is rounded laterally, and flattened in the longitudinal direction, the mouth-opening is situated at some distance behind the sulcus, the peristome is transversely oblong, and the under lip forms a strong projecting process of the shell (fig. 1 *c* and fig. 2 *b*).

Affinities and Differences.—I have already pointed out (pp. 275, 279) the affinities which this Urchin has with *Micraster cor-anguinum* on the one side, and with *Micraster breviporus* and *Micraster cor-bovis* on the other, and have stated how difficult it is to detect any characters of specific value by which it may be described as distinct from either. I have long considered *M. cor-testudinarium* as a variety of *M. cor-anguinum*. The backward position of the mouth-opening, the flatness of the upper surface, and more cordate shape of the test, are not characters of specific value, although they may be useful in establishing the fact that varieties lived under special conditions in the Cretaceous sea, and a separation of the varieties may, therefore, be of value for stratigraphical purposes.

Stratigraphical Position.—Mr. Meÿer regards *M. cor-testudinarium* as a characteristic fossil of the Dover chalk, and *M. cor-anguinum* of the Charlton Chalk which belongs to a much higher bed in the Cretaceous series;[1] and this appears to correspond with the horizons in which these forms are found in France and North Germany.

Herr Struckmann's specimens of *Micraster cor-testudinarium*, Goldf., were all obtained from the Middle Plæner of Hanover, and very much resemble the English Urchins collected from the cuttings of the Surrey and Sussex Railway,—so much so that, were they not carefully marked, the English and German forms could not be distinguished from each other. Two of the specimens were collected from the Middle Plæner of Weddingen near Liebenburg, and the largest of these is figured in Pl. LXXVI, fig. 1 *a*, *b*. The details of the anatomy of the test are given in fig. 1 *c*, showing the backward position of the

[1] C. Evans "On Forms of the Genus Micraster," 'Proc. Geol. Assoc.,' vol. v, No. 4, p. 3, 1877.

mouth-opening and the width of base; fig. 1 *d* shows three large interambulacral plates, with numerous irregular rows of tubercles on each set in an abundant microscopic granulation, with parts of the petaloid and non-petaloid portions of the ambulacral area magnified to show the wide-set disposition of the pores in the poriferous zone in the petaloidal, and their very different condition in the nonpetaloidal parts; fig. 1 *e* shows the size and distribution of the smaller tubercles, and fig. 1 *f* the size and structure of the larger tubercles, where each tubercle is seen encircled by a smooth areola, with a circle of granules disposed around the margin thereof; fig. 2 *d*[1] exhibits the structure of the apical disc, and shows the four ovarial plates with very large holes, having the five ocular plates arranged alternately with the ovarials, and the large madreporiform body covering the central portion of the disc. A third specimen, which resembles very much the one I have figured, was collected from Othfresau near Liebenburg. The fourth specimen resembles the *breviporus* variety, and was found at Langelsheim, near Gosler, Hanover.

When we compare Herr Struckmann's specimens with the figures in Goldfuss's 'Petref. Germaniæ,' pl. xlviii, fig. 5 *a*, *b*, we see that the type specimen was shorter, broader, and more globular than the Hanoverian Urchins, and that the specimen, fig. 5 *d*, of smaller size, very much resembles the English Urchins from Purley figured in Pl. LXXVI, fig. 2 *a*, of this work. The types figured by Prof. Goldfuss were collected from the Chalk of Westphalia, and other examples are recorded from the White Chalk of Maestricht and Quedlinburg, and from the Hard or Lower Chalk of Coesfield.

In Belgium, France, and Germany two zones of Chalk have been recognised by Continental geologists, characterised respectively by *Micraster cor-anguinum* and *M. cor-testudinarium*, the former characteristic of our Charlton Chalk, and the latter of the Dover Chalk; and these, it has been shown by Mr. Meÿer, F.G.S., and Mr. Caleb Evans, F.G.S.,[2] who have paid special attention to this subject, exist in England.

In 1876 Dr. Charles Barrois published a very valuable memoir on "*le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande*," in which he described the Chalk of the South Downs and the Hampshire Basin, and most other parts of England and Ireland, and has clearly shown that it is possible to correlate the zones of life in the English Chalk with corresponding zones which he has already established in the Chalk of France. Mr. Caleb Evans contributed to the Geologists' Association in 1877, a valuable paper,[2] with figures of species, "On the Forms of the Genus *Micraster* common in the Chalk of West Kent and East Surrey," in which he pointed out the distribution of the species in these zones.

The classification which Dr. Barrois adopts is shown in the following Table, to which I have added the English equivalents of the same as identified by Mr. Caleb Evans.

[1] In the lettering of this plate the numerals 1 *d* have been twice repeated; that of the apical disc should be 2 *d*.

[2] 'Proceedings of the Geologists' Association,' vol. v, No. 4, p. 149, 1877.

Dr. Barrois' General Classification.	Mr. C. Evans' Classification in East Surrey and West Kent.
Zone à *Belemnitella.*	Gravesend Beds?
„ *Marsupites.*	
„ *M. cor-anguinum.*	Charlton and Croydon Beds.
„ *M. cor-testudinarium.*	Riddlesdown Beds.
„ *Holaster planus.*	Kenley Beds.
„ *Terebratulina gracilis.*	Whiteleaf Beds.
„ *Inoceramus labiatus.*	Upper Marden-Park Beds.
„ *Belemnites plenus.*	Lower Marden-Park Beds.
„ *Holaster sub-globosus.*	Oxtead Beds.
Zone à *Pecten asper.*	
„ *Ammonites inflatus.*	

MICRASTER BREVIS, *Desor.* Pl. LXXV, figs. 2 *d*, 3 *a—g*.

MICRASTER LATUS,	*Sismonda.*	Echin. foss. de Nizza, p. 29, tab. i, fig. 13, 1843.
— BREVIS	*Hébert.*	Étud. sur les terr. Crétacés ; Mém. Soc. Géol. de France, 2e ser., tom. v, tab. xxix, fig. 19, 1854.
SPATANGUS ANANCHYTOIDES,	*Desmoul.*	Tabl. Synom., p. 406, 1837.
MICRASTER BREVIS,	*Desor.*	Synopsis des Échinides Foss., p. 364, 1858.

Diagnosis.—Test cordiform, very short, as broad as it is long ; antero-lateral ambulacra long and wide, postero-lateral pair shorter ; poriferous zones wide, holes forming a pair placed far apart. Test elevated, sometimes conoidal ; anteal sulcus very shallow ; single ambulacrum similar in structure to the anterior pair ; posterior border narrow and very obliquely truncated.

Description.—This Urchin appears to belong to the "*Craie à hippurites*" and has many structural affinities with certain forms of *M. cor-testudinarium ;* it is, however, a much wider shell with a more elevated upper surface, and as far as external form goes very different from that species ; the summit is excentral, a little nearer the anterior border. The ambulacral areas are built of narrow elongated plates, and the pores forming a pair are placed wider apart than in any of the congeneric forms I have described.

My late friend, Monsieur Michelin, sent me several very good type shells from the "*Craie à hippurites*" from Sougraigne, near les Bains de Rennes, and Soulage, Corbières, Aude ; it is found also at Tuco, near Caseneuve, "Craie de Tercis au Périgord

étage Senonien." Among the many varieties of Micrasters collected from the Chalk rocks of the British Islands, I have seen no form that I can assign to *Micraster brevis*. I have given a drawing of a good type form of this species for reference should any forms allied to it be discovered in course of time; and have furnished numerous details for special comparison. The wide ambulacra, with narrow elongated plates and wide-set pores in the zones, the character of the tubercles in the plates (fig. 3 *f* and *g*), the structure of the apical disc, with the uniform structural character of the five ambulacra, form an assemblage of points of structure which are very diagnostic of this species. My learned friend, Monsieur Cotteau, considers this form to be a variety only of *M. cor-testudinarium;* in reviewing the different varieties of this species he remarks,[1] "in the south-west of France, and in the basin of the Mediterranean, the variety which predominates is short and dilated before, and wider than it is long. It is the *M. brevis*, Desor, which we can collect by hundreds in the quarries of Villedieu and of Saint-Fraimbault, and in the Chalk of Corbières at Sougraigne and at Soulage (Aude)."

CATOPYGUS PYRIFORMIS, *Goldfuss*. Pl. LXXVIII, fig. 2 *a*, *b*, *c*.

NUCLEOLITES	PYRIFORMIS,	*Goldfuss*.	Petref. Germaniæ, p. 141, pl. 43, fig. 7, 1829.
CATOPYGUS	—	*Agassiz and Desor*.	Catal. raison. R. 6, An Sciences Nat., tom. 7, ser. 3, p. 158, 1847.
—	TENUIPORUS,	—	Ibid., ibid., R. 7.
—	PYRIFORMIS,	*d'Orbigny*.	Prodrome II, p. 271, Étage 22, 1850.

Diagnosis.—Test ovate, posterior border produced and tapering, upper surface depressed, posterior half most elevated and slightly carinated; ambitus inflated, posterior border narrow, truncated, vent in the middle covered by the beak-shaped termination of carina, base flat, plastron elevated, oral aperture central, surrounded by five prominent lobes with petaloidal expansions proceeding therefrom; ambulacral areas narrow, equal sized, poriferous zones with 10—12 pairs of pores set obliquely and well spaced out; periprocte oblong, transverse, test thick, external surface covered with fine, close-set granules lodged in depressed areolæ excavated out of the test like the small concavities around the top of a thimble, those on the base larger than those of the upper surface.

Dimensions.—Antero-posterior diameter $\frac{9}{10}$ of an inch; transverse diameter across the widest part of ambitus $\frac{7}{10}$ of an inch; height $\frac{5}{10}$ of an inch.

Description.—I am indebted to Mr. E. T. Newton, F.G.S., Palæontologist of the Survey, for calling my attention to this very beautiful Urchin, obtained by Mr. J. F. Walker, F.G.S., of York, and said to have been collected from the Upper Greensand of Warminster. This specimen was presented by him to the Museum of the Royal School of Mines, Jermyn Street, where it is now contained. A careful examination of

[1] 'Échinides du Départ. de la Sarthe,' p. 323, 1861.

the matrix of this Urchin has, however, raised doubts in my mind as to the accuracy of the stratum and locality. Mr. Walker it appears bought it from a dealer in Warminster, who may have had it in exchange along with some foreign specimens. *Catopygus pyriformis* is found in the Senonian of Maestricht, Ciply, and Sens, Yonne, and is a very characteristic Urchin of this stage of the Cretaceous formations.

The following description and figures of a new species of *Pseudodiadema* have been forwarded to me by my valued friend, the Rev. Professor Thos. Wiltshire, F.G.S., as a contribution to my Addenda.

PSEUDODIADEMA FRAGILE, *Wiltshire*. Pl. LXXX, figs. 1—11.

"Test somewhat small, thin, circular, depressed, almost flat on upper surface, slightly convex on under. Poriferous zones narrow, straight, pores unigeminal on upper surface, trigeminal on lower. Ambulacra narrow above, rather wider below, with two rows of small perforated tubercles from oral aperture to above ambitus. Interambulacral wide, two rows of small primary perforated tubercles in the middle extending the whole distance, and two rows of secondary perforated tubercles on lower side, ceasing after passing the ambitus. Miliary zone granular below, showing a few secondary tubercles above and below the ambitus. Mouth-opening large, peristome circular, lobed. Discal opening large, pentangular. Spines small, slender, straight; surface striated, striæ interrupted and diverging, and producing a roughened surface.

Dimensions.—Height less than $\frac{1}{2}$ inch, transverse diameter $1\frac{1}{2}$ inches.

Description.—The test is thin, circular, almost flat on upper surface, slightly rounded on under. In the specimen from which the drawings were made the upper and under sides, prior to their fossilisation, had been subjected to considerable pressure, and brought into closer contact than they were in the living stage. The distance between the upper and the under sides therefore cannot be accurately determined; probably the figured specimen was under half an inch in height.

The ambulacral areas are straight and narrow (about two-ninths the width of the ambulacra at the upper side, and nearly one-half at the peristome), contracting in their range upwards. Two rows of about nine perforated tubercles (one tubercle to each plate) start from the under side, and cease soon after passing the ambitus. The tubercles are small, placed in small areolæ, with slightly projecting bosses and crenulated summits, and are separated by an undulating series of granulations. The poriferous zones are narrow and straight. The pores are oval and simple, and are arranged in single file throughout the zones, save near the peristome, where they form into a few transverse lines of sets of three pores.

The interambulacral areas are four times the width of the ambulacral at the equator,

and are throughout much wider than the latter. On the under side they have four rows of small perforated primary tubercles, crenulated, and slightly raised above a smooth areola, whose margin is generally surrounded by granules. The two inner rows are best developed, and extend from the peristome to the discal margin; the two exterior rows are absent from the uppermost plates. The figured specimen (figs. 6, 11) seems to have had ten tubercles in the inner rows. The miliary zone is narrow in the inframarginal region, is wider in the middle, and expands at the upper side; it is filled with small irregularly placed granules, among which, on the upper side near the junction of plates, are a few mamillated tubercles, one on each plate.

The spines (figs. 3, 8) are extremely fine, needle-shaped, rather longer than twice the width of the plates of the ambitus; are solid, though occasionally longitudinal internal cavities exist. The surface is sculptured with fine long lines, and is marked by alternate angular contractions and expansions, so that the section lengthways is serrate, but circular in the opposite direction. A representation of a similar spine will be found in Pl. XIV, fig. 2 *c*.

Locality and Stratigraphical Position.—The very rare Urchin illustrated on Pl. LXXX, figs. 1—11 was obtained many years since by myself from the Upper Chalk at Gravesend. When the fossil was first discovered it exhibited no more than the inner surface of the plates of the upper side. Indications, however, were not wanting to show that the fracture of the piece of chalk containing the Pseudodiadema had split the test into two halves, along the plane of the ambitus, and that the second piece of chalk which bore the impression of these plates (and which fortunately had been saved) contained the under plates of the Urchin. The two halves were afterwards mounted on plaster of Paris, and carefully cleaned until the parts of the test previously concealed began to appear. In the removal of the chalk evidence was given that several extremely fine hair-like spines, with a striated and quasi-imbricated exterior, were in contact with or close to the test, and were the spines of the Urchin. Such spines are occasionally met with in the Upper Chalk, and solitary plates similar to those depicted in figs. 1, 5, are found in the same geological horizon. It is very unusual for the plates and spines to be associated together as in the present instance.

Affinities and Differences.—*Pseudodiadema fragile* has some resemblance to *Pseudodiadema ornatum* of the Lower Chalk, but can be distinguished by its smaller and widely separated tubercles, the general smooth surface of its test, and its spines with their series of short longitudinal striations, which by their divergence form a succession of fringes. The circumstance that the plates of this Urchin are generally found separated from one another has suggested the specific name of *fragile*."

At pages 1—14 I gave an account of the subdivisions of the Cretaceous beds of England as they were recognised at that period when that part of my Monograph was

written, viz. in the year 1864. I append now, however, as a conclusion to my work, the following remarks by A. J. Jukes-Brown, Esq., F.G.S., on a proposed new classification of the English Chalk.

"English geologists have hitherto been accustomed to divide the Chalk into three portions, which have long been known by the name of: (1) Chalk Marl; (2) Lower Chalk, without flints; (3) Upper Chalk, with flints. But recent researches have shown that such an arrangement is not supported by either stratigraphical or palæontological evidence, and that the divisions above named do not constitute natural rock-groups. It is time, therefore, that a new nomenclature should be introduced, founded on a better system of classification.

"D'Orbigny's divisions of Cenomanian, Turonian, and Senonian have long been adopted on the Continent, and in 1875 they were applied to the English Chalk by Dr. Ch. Barrois, who found that even the zonal subdivisions of the system were substantially the same in both countries.[1] That system might be accepted in England.

The zones of the English Chalk in the Eastern and Southern Counties may be thus stated on the authority of the respective authors whose names are appended.

	Cambridgeshire. Jukes-Brown.	Norfolk. Woodward.	Kent. Price.	Dorset. Barrois.
Upper.	Upper zones concealed	Upper Chalk	Upper Chalk	Zone à Belemnitelles.
				Zone à Marsupites.
	Zone of Micrasters			Zone à Micraster.
Middle.	Chalk Rock	?	Chalk with flints	Zone à *Holaster planus.*
	Zone of *Holaster planus*			
	Zone of *Terebratulina gracilis*	Medial Chalk and part of the Lower Chalk	Zone of *Terebratulina gracilis*	Zone à *Terebratulina gracilis.*
	Zone of *Rhynchonella Cuvieri*		Zone of *Cardiaster pygmæus*	Zone à *Inoceramus labiatus.*
	Melbourn Rock	?	Belemnite Marl	Marne à *Belemnites plenus.*
Lower.	Zone of *Holaster subglobosus*	Hunstanton Chalk	Zone of *Holaster subglobosus*	Zone à *Holaster subglobosus.*
	Totternhoe Stone	? Inoceramus bed	Zone of *Ammonites varians*	
	Zone of *Rhynchonella Martini*	? Absent	Chalk Marl	
	Cambridge Greensand	Red Chalk in part	Chloritic Marl	Zone à *Pecten asper.*

"It will be seen from the above that the Lower Chalk, may be defined as including the three minor divisions hitherto called Chloritic Marl, Chalk Marl, and Grey Chalk; the Totternhoe Stone being only a local development of sandy stone between the two latter. The Lower Chalk will therefore correspond with the Cenomanian of D'Orbigny. It is characterised by an abundance of Cephalopods, Ammonites, Turrilites, Scaphites and Nautili. The most characteristic species are *Ammonites Mantelli, Am. varians, Am. Rhotomagensis, Lima globosa, Plicatula inflata, Rhynchonella Martini, Holaster subglobosus, H. lævis* and *Discoidea subucula.*

[1] Recherches sur le Terrain Crétacé Supérieur de l'Angleterre et de l'Irlande. Lille, 1876.

"The Middle Chalk may be taken to include the greater part of that formerly known as the Lower Chalk, and will answer to the French Turonian. Its fauna is very different from that of the beds below, most of the Cenomanian species having died out during the interval marked by the formation of the Melbourn Rock, while other new species were introduced, the chief of these being *Ammonites nodosoides*, *Am. peramplus*, *Inoceramus mytiloides*, *Rhynchonella Cuvieri*, *Echinoconus subrotundus*, *Cyphosoma simplex*, *Cardiaster pygmæus*, and *Holaster planus*.

"The Upper Chalk may be regarded as equivalent to the Senonian of the French. It is characterised by the abundance of *Micraster coranguinum*, *Cidaris sceptrifera*, *Terebratula carnea*, *Lima Hoperi*, and in the higher zones by *Marsupites ornatus*, *Echinoconus conicus* and *Belemnitella mucronata*."

APPENDIX I.

SUMMARY[1] OF THE BRITISH CRETACEOUS ECHINOIDEA.

Order—ECHINOIDEA, *Wright* (p. 19).

Body-shell (*test*) spheroidal, oval, cordate, or depressed, without arms, furnished with a distinct mouth (*oral opening*), whose border (*peristome*) is sometimes simple, sometimes lobed, always placed either in the centre or forwards on the under side; when the oral opening is not central its position marks the anterior region; armed with five calcareous sets of plates (*jaws*), or not armed (*edentulous*). Anal opening (*vent, periprocte, discal opening*) variously situated on the upper (*dorsal*) or under (*basal*) side in the centre (*central*) or away from the centre (*excentral*), or in intermediate positions on the marginal border (*circumference, ambitus, equator*). Body enclosed in a shell (*test*) composed usually of twenty, sometimes of more than twenty (as in the family of the Palæozoic *Perischoechinidæ*), columns of calcareous plates, forming in either case ten areas; plates either solidly connected or capable of movement. Five of the areas (*ambulacral*) narrow or wide, containing each two rows of apertures (*poriferous zones*) for the passage (in the living state) of retractile suckers (*ambulacral tubes*). The other five areas (*interambulacral*) more or less wide, destitute of sucker pores. Ambulacral pores disposed in single pairs (*unigeminal*), double (*bigeminal*), or triple oblique (*trigeminal*). Ambulacral pore-columns (*areas*) sometimes continuous from the peristome to the summit (*complete*), sometimes confined to the upper surface of the test (*interrupted*), or forming re-entering curves (*petaloid*). Surface of test studded with tubercles (*primary, secondary,* and *miliary*), possessing spines of various forms and dimensions, solid or hollow, smooth, striated, serrated. Spines articulated on the rounded upper part of a tubercle (*mamelon*) which rises from a conical process (*boss*). Base of tubercle surrounded by a round, oval, smooth, excavated space (*areola* or *scrobicule*). Summit of test marked by an apical (*genital*) disc, composed generally of five genital and five ocular plates, usually in contact and central. Cutaneous surface of shell, especially near the mouth, bearing in the living stage small, tripartite, pincer-like bodies (*pedicellariæ*), placed on a short stalk, whose

[1] Compiled by the Rev. Prof. Thos. Wiltshire, M.A., F.G.S., Hon. Sec. Pal. Soc.

lower portion encloses a calcareous nucleus. Pedicellariæ capable (in the living state) of seizing small bodies and passing them from one to the other. Movement of the animal effected by the motion of the spines and the ambulacral tubes.

The Echinoidea (including the Perischoechinidæ) range from the Silurian to the existing period, and are represented in the British Cretaceous formation by ten families (Cidaridæ, Diademadæ, Saleniadæ, Echinothuridæ, Echiniconidæ, Echinonidæ, Echinobrissidæ, Echinolampidæ, Spatangidæ, and Echinocoridæ), and give thirty Cretaceous genera in one hundred and thirteen species, and are divisible into one Palæozoic section, the Palechinoidea, with more than twenty rows of plates, and two Mesozoic and Cainozoic sections, the Echinoidea endocyclica and the Echinoidea exocyclica, wfth twenty rows of plates.

Section A.—Echinoidea endocyclica, *Wright* (p. 29).

Anal opening within the genital plates, always opposite the mouth. Jaws always present.

The section includes six families: Cidaridæ, Hemicidaridæ, Diademadæ, Echinidæ, Saleniadæ, and Echinothuridæ, ranging from the Trias to the existing period. Four families (Cidaridæ, Diademadæ, Saleniadæ, and Echinothuridæ) are represented in the British Cretaceous strata, and give eleven genera: Cidaris, Pseudodiadema, Pedinopsis, Echinocyphus, Glyphocyphus, Cyphosoma, Peltastes, Goniophorus, Salenia, Cottaldia, and Echinothuria, consisting of fifty-nine species.

Family I.—CIDARIDÆ, *Wright* (p. 35).

Test thick, spheroidal, generally depressed at the upper and under surfaces. Ambulacral areas narrow, usually undulating, and destitute of primary tubercles. Interambulacral areas wide, carrying a few large primary perforated tubercles. Poriferous zones narrow; pores generally unigeminal. Oral and anal openings large. Peristome destitute of notches. Apical disc large, composed of five large, equal-sized, angular genital plates, and five ocular plates. Jaws large. Primary spines long, massive, and more or less cylindrical. Family ranging from the Trias to the existing period, and represented in the British Cretaceous strata by one genus, Cidaris, with seventeen species (pp. 35—79).

Genus 1.—Cidaris, *Klein* (p. 35).

Test thick, more or less depressed. Ambulacral areas undulating. Primary tubercles few, rarely more than six in a row. Miliary zones more or less wide. Pores of the

poriferous zones unigeminal and contiguous. Range of genus, from the Trias to the existing period. Seventeen British Cretaceous species (pp. 36—79).

Family II.—DIADEMADÆ, *Wright* (p. 80).

Test in general moderately thick, subpentagonal, more or less depressed. Ambulacral areas almost always straight, more or less wide, furnished with two or four rows of tubercles often as large as those of the interambulacral. Interambulacral areas equal to, or double as wide as, the ambulacral. Tubercles of the interambulacral areas crenulated or non-crenulated, either primary, of equal size, in two to eight rows, generally perforated, or with two or four rows of secondary tubercles, much smaller in size, filling up the interspaces of the area. Poriferous zones narrow and almost always straight; pores unigeminal, bigeminal, or trigeminal. Oral and anal openings usually large. Peristome strongly decagonal, generally deeply notched. Spines cylindrical, solid or tubular. Those of the fossil not longer than the diameter of the shell; surface of the solid forms covered with very fine minute longitudinal striæ; and those of the tubular with oblique annulations of fringe-like scales. Jaws large. Range of family, from the Trias to the existing period. Family represented in the British Cretaceous strata by five genera: Pseudodiadema, Pedinopsis, Echinocyphus, Glyphocyphus, Cyphosoma, and by twenty-three species (pp. 87—124, 341, 342).

Genus 2.—Pseudodiadema, *Desor* (p. 86).

Test moderately thick, generally not large. Ambulacral areas one third to one half the width of the interambulacral. Ambulacral areas furnished with two rows of primary tubercles. Interambulacral areas sometimes provided with two rows of primary tubercles, sometimes with two rows of primary and two to four short rows of smaller secondary tubercles, sometimes with four or six rows of nearly equal-sized primary tubercles at the equator. Primary tubercles of both areas perforated, having sharply-crenulated summits. Poriferous zones narrow and straight; pores of poriferous zones unigeminal throughout, or bigeminal in the upper part of the zones. Oral opening large. Peristome deeply notched. Anal opening pentangular. Spines solid, cylindrical or needle-shaped, short, and covered longitudinally with very minute microscopic lines. Range of genus, from the Lias to the Upper Cretaceous beds. Twelve British Cretaceous species (pp. 87—113, 341, 342).

Genus 3.—Pedinopsis, *Cotteau* (p. 113).

Test thin, of moderate size, inflated, sometimes subconical. Ambulacral areas rather wide, furnished with two complete and two incomplete rows of small perforated and

crenulated tubercles. Interambulacral areas marked at ambitus by six to ten lines of perforated and crenulated tubercles, decreasing in number above and below until only two lines remain. Poriferous zones wide and straight; the pores bigeminal throughout, and forming at the upper surface and ambitus two distinct rows, becoming blended together at the inframarginal region and remaining conspicuous at the base. Oral opening subcircular and lobed. Apical disc small. Spines unknown. The genus is only met with in the Cretaceous strata. One British Cretaceous species (pp. 114—116).

Genus 4.—Echinocyphus, *Cotteau* (p. 116).

Test thin, small, circular, more or less inflated on the upper surface, concave at the base. Ambulacral areas rather wide, furnished with one, rarely two, rows of primary tubercles. Interambulacral areas with two rows of tubercles. Tubercles of both areas of nearly the same size, alternate, crenulated, but not perforated. Interambulacral plates of base sculptured, with more or less strongly marked sutural depressions, and exhibiting on their surface a border of radiating miliary granules. Poriferous zones nearly straight, narrow; pores unigeminal. Oral opening moderately large, subcircular, provided with slight lobes. Anal opening of same size. Apical disc unknown. Spines unknown. The genus is only met with in the Cretaceous strata. Two British Cretaceous species (pp. 116—119).

Genus 5.—Glyphocyphus, *Haime* (p. 120).

Test thin, small, circular, more or less inflated above, concave below. Ambulacral areas somewhat narrow, generally with two rows of alternate tubercles, sometimes with only one row. Interambulacral areas with two rows of alternate tubercles. Tubercles of both areas of nearly the same size, crenulated and perforated. Ambulacral and interambulacral plates marked by sutural depressions; surface around the tubercles covered with fine, close-set, homogeneous granules. Poriferous zones straight, narrow; pores unigeminal. Oral opening small, subcircular, divided into lobes by feeble incisions. Anal opening not large, subpentagonal. Apical disc small, solidly united to the test, forming an elongated oval ring. Spines unknown. The genus confined to the Cretaceous strata. One British Cretaceous species (pp. 121—124).

Genus 6.—Cyphosoma, *Agassiz* (p. 128).

Test thick, moderate in size, circular or subpentagonal. Sides slightly inflated, depressed, convex above, flattened below. Ambulacral areas furnished with two rows of prominent crenulated and imperforate primary tubercles. Interambulacral narrow

above, wide below, with two perfect and sometimes two imperfect rows of prominent crenulated and imperforate primary tubercles; the two perfect rows close together at the peristome and wide apart at the anal opening. Primary tubercles of the same size in both areas. Poriferous zones well developed, straight on upper side, undulating at the ambitus and base; poriferous plates unequal and irregular. Pores unigeminal, more or less bigeminal on upper surface and crowded together at the peristome. Oral opening large, subcircular, incised and lobed. Anal opening large, pentagonal, the angles extending into the middle portion of the interambulacra. Elements of anal disc feebly united. Spines long, solid, of moderate thickness, cylindrical, aciculate, spatuliform or spoon-shaped. The genus confined to the Cretaceous strata. Seven British Cretaceous species (pp. 129—144.

Family III.—SALENIADÆ, *Wright*, (p. 144).

Test thin, small, spheroidal, hemispherical or depressed. Ambulacral areas wide or narrow, straight or flexuous, furnished with two rows of secondary tubercles alternating with each other on the margins of the area. Interambulacral areas wide, having two rows of primary, crenulated tubercles perforate or imperforate. Poriferous zones narrow. Pores unigeminal, except near the peristome where they fall into oblique rows of three. Oral opening sometimes small, sometimes large, more or less decagonal, deeply or feebly indented. Anal opening sometimes small. Apical disc large or small, pentagonal or undulated, much developed, carrying a suranal plate in the middle of the disc, consisting of one to eight separate elements. Periprocte excentric. Spines long, slender, straight, curved, angular or flattened, ovoid or subglandiform. Family ranging from the Jurassic to the existing period, and represented in the British Cretaceous strata by four genera: Peltastes, Goniophorus, Salenia, Cottaldia, in eighteen species (pp. 149—189).

Genus 7.—Peltastes, *Agassiz* (p. 149).

Test thin, small, circular, more or less inflated above, almost flat below. Ambulacral areas narrow, straight, or slightly flexuous, furnished with two rows of small, close-set, alternating secondary imperforate tubercles. Interambulacra large, provided with two rows of large crenulated, imperforate tubercles. Poriferous zones narrow. Pores unigeminal, crowded near the peristome. Oral opening moderate in size. Peristome slightly incised, unequally lobed. Apical disc generally large and solid, projecting above the surface, marked by impressions and striæ, shield shaped, composed of large plates more or less undulated at the border. The right antero-lateral ovarial provided with an oblong fissure always directed from right to left and corresponding to the

oviductal pore and representing the madreporiform body. Periprocte excentric, elliptical, its minor axis in a line with and near to one of the ambulacral areas. Spines slender, striated. Range of genus, from the Lower Cretaceous to the existing period. Seven British Cretaceous species (pp. 150—162).

Genus 8.—Goniophorus, *Agassiz* (p. 165).

Test thin, circular, elevated above, flat below. Ambulacral areas narrow, slightly undulating, with two rows of secondary alternate imperforate tubercles. Interambulacral areas wide, marked by two rows of primary, alternate, crenulated tubercles. Poriferous zones narrow. Pores simple unigeminal. Oral opening small. Peristome decagonal, slightly incised, and equally lobed. Apical disc large, regularly pentagonal, smooth without incised impressions, ornamented with prominent carinæ independent of the form of the ovarial plates. Periprocte excentric, rhomboidal, elliptical, with its minor axis in a line with but distant from one of the ambulacral areas. Disc composed of five ovarial and five ocular plates, and one suranal. Genus confined to Cretaceous strata. One British species (pp. 166—169).

Genus 9.—Salenia, *Gray* (p. 169).

Test thin, small, circular, elevated, sides inflated, more or less convex above, flat beneath. Ambulacral areas narrow, gently flexuous, with two or four rows of equal-sized secondary imperforate tubercles. Interambulacral areas wide, with two rows of primary, crenulate, imperforate tubercles. Poriferous zones narrow, pores unigeminal, crowded near the peristome. Oral opening large. Peristome feebly incised, unequally lobed. Apical disc large, shield shaped with deeply undulated border. The ovarial and suranal plates large and pentagonal, the oculars wide and cordate with punctured or incised sutures. Surface of plates smooth, granulated, or striated. Periprocte sub-circular, excentric, and variable in position in the different species, but on the right side of a line passing through the axis of the body. Spines long and slender, aciculate or spatulate, straight or bent. Range of genus, from the Lower Cretaceous strata to the existing period. Nine British Cretaceous species (170—186).

Genus 10.—Cottaldia, *Desor* (p. 186).

Test extremely thin, small, circular, inflated, more or less depressed. Ambulacral areas moderately narrow, furnished with numerous small mamillated, imperforate, uncrenulate tubercles, one row to each plate. Ambulacral areas moderately wide, with numerous small equal-sized, imperforate, uncrenulate tubercles, one row to each plate. Poriferous zones straight. Oral opening depressed, large, circular, slightly decagonal, feebly notched. Apical disc solid, narrow, forming a prominent ring composed of five

perforated, rhomboidal ovarial plates, and five cordate oculars, much granulated. Periprocte small. Spines unknown. Range of genus, from the Upper Greensand to the existing period. One British Cretaceous species (pp. 187—189).

Family IV.—ECHINOTHURIDÆ, *Wyv. Thomson.*

Test thin, circular, flexible, plates more or less overlapping, those of the ambulacral areas imbricating from below upwards, those of the interambulacral from above downwards. Under and upper sides sometimes very different. Ambulacral and interambulacral areas carrying primary perforated tubercles, and scattered secondary tubercles and granules. Poriferous zones with three pairs of pores. Oral and anal openings large. Oral opening protected by scale-like plates. Jaws strong. Spines thin, hollow, with projecting processes arranged in an imperfect spiral. Range of family, from the Cretaceous to the existing period. One British Cretaceous genus (Echinothuria) and one species.

Genus 11.—Echinothuria, *Woodward* (p. 124).

Test circular; depressed, plates slightly overlapping. Ambulacral plates narrow, long, imbricating from the anal aperture towards the oral aperture. Interambulacral plates arranged in the reverse order. Ambulacral plates containing two smaller plates, each perforated by a pair of pores intercalated in a notch in the middle of the lower margin, and perforated by a third pair of pores nearer the interambulacral areas. Primary tubercles of the ambulacra perforated, few, and irregularly distributed. Alternate plates of the interambulacral areas bearing one perforated primary tubercle. Oral opening large. Spines small, slender, striated, fringed. One British Cretaceous species (pp. 125—127).

Section B.—Echinoidea exocyclica, *Wright* (p. 29).

Anal opening outside the genital plates, never opposite the mouth.

The section contains eight families: Echinoconidæ, Collyritidæ, Echinonidæ, Echinobrissidæ, Echinolampidæ, Clypeasteridæ, Echinocoridæ, Spatangidæ, and ranges from the Liassic to the existing period. Six families (Echinoconidæ, Echinonidæ, Echinobrissidæ, Echinolampidæ, Spatangidæ, Echinocoridæ), are represented in the British Cretaceous strata by nineteen genera: Discoidea, Echinoconus, Holectypus, Pyrina, Catopygus, Clypeopygus, Echinobrissus, Trematopygus, Caratomus, Pygurus, Hemiaster, Epiaster, Micraster, Echinospatagus, Enallaster, Cardiaster, Infulaster, Holaster, Echinocorys; and by fifty-four species.

Family V.—ECHINOCONIDÆ, *Wright* (p. 198).

Test thin, circular, elongated or pentangular, elevated or depressed. Ambulacral areas narrow. Interambulacral areas wide. Both areas covered with numerous small perforated and crenulated tubercles. Poriferous zones simple, narrow, straight. Pores unigeminal except near the peristome, where they are trigeminal. Oral opening on under side central, circular, or pentagonal, notched into ten nearly equal lobes armed with five jaws. Apical disc central on upper side, composed of five ovarial and five ocular plates, madriporiform body very large, extending from the right antero-lateral ovarial plate into the centre of the disc. Anal opening variable in position on upper, lower, or marginal surface. Spines small, short, subulate. Range of family, from the Lower Oolites to Upper Chalk. Three British Cretaceous genera: Discoidea, Echinoconus and Holectypus, with eleven species (pp. 198—234).

Genus 12.—Discoidea, *Klein* (p. 199).

Test thin, circular, hemispherical, elevated. Ambulacral areas straight, narrow. Interambulacral wide, covered with numerous small, perforated, crenulated tubercles. On the inner side surface of the interambulacral plates near the poriferous zones are thick, shelly processes projecting inwards and forming small septa. Poriferous zones very narrow. Oral opening small, circular. Peristome decagonal, marked by slight notches. Anal opening oval, always inferior, and placed between the peristome and border, covered with small irregular granular plates. Apical disc solid, forming a slight projection on the summit of the test, having four or five perforated and one imperforate ovarial plates. Spines short and stout. Range of genus, from the Upper Greensand to the White Chalk. Five British Cretaceous species (pp. 200—213).

Genus 13.—Echinoconus, *Breynius* (p. 213).

Test thin, round, oval or pentagonal, enlarged a little before and slightly contracted behind. Upper surface more or less elevated, rounded or conoidal, under surface flat, sometimes concave. Ambulacral areas lanceolate. Interambulacra wide. Tubercles perforated and crenulated. Poriferous zones straight, narrow. Pores unigeminal becoming trigeminal at the peristome. Oral opening central, small, circular. Peristome subdecagonal, notched. Jaws present. Apical disc solid, placed at summit, having four perforate and one imperforate ovarial plates. Ocular plates very small and interposed between the angles of the ovarials. Spines small, acicular. Range of genus, from the Upper Greensand to the Upper Chalk. Five British Cretaceous species (pp. 213—231).

Genus 14.—Holectypus, *Desor* (p. 231).

Test thin, circular or subcircular, more or less hemispherical, conical or subconical, always tumid at the sides and flat or concave at the base. Ambulacral areas narrow, straight, lanceolate, with six or eight rows of small, perforated and crenulated tubercles, of which the marginal series only extend from the base to the apex. Poriferous zones narrow, pores unigeminal throughout. Interambulacral areas wide, furnished with small perforated and crenulated tubercles. Interambulacral plates not carrying on the inner surface projecting plates. Oral opening circular, central. Peristome notched. Jaws present. Apical disc central, vertical, composed of five ovarial and five ocular plates. The right antero-lateral much the larger and supporting a prominent madriporiform body. In Oolitic species, anterior and posterior plates perforated, and single plate imperforate; in Cretaceous species all the plates perforated. Anal opening large, inframarginal rarely, marginal sometimes occupying the centre space between peristome and border. Spines short, longitudinally striated. Range of genus, from the Inferior Oolite to the Lower Chalk. One British Cretaceous species (pp. 233, 234).

Family VI.—ECHINONIDÆ, *Wright* (p. 234).

Test thin, oval, or round, depressed. Ambulacral areas small, lanceolate. Interambulacral wide. Plates of both areas furnished with small, equal-sized imperforate and noncrenulate tubercles. Oral opening subcentral, irregularly pentagonal. Jaws absent. Apical disc nearly central, four ovarial plates perforated, one imperforate. Anal opening oblong, pyriform, basal or marginal closed by plates. Range of family, from the Cretaceous rocks to the existing period. One British Cretaceous genus: Pyrina, and three species (pp. 235—239).

Genus 15.—Pyrina, *Desmoulins* (p. 235).

Test thin, oval or round, depressed or globular; under surface inflated and often depressed around the mouth opening. Ambulacral areas moderately narrow, lanceolate. Interambulacral areas wide. Both areas covered with small equal-sized and imperforate tubercles. Poriferous zones straight and narrow, pores in regular pairs. Oral opening oval, oblique, subcentral. Peristome destitute of lobes. Apical disc small, subcentral, with four perforated genital plates. Anal opening oval and marginal, generally nearer the upper than the under surface. Spines unknown. Three British Cretaceous species (pp. 236—239).

Family VII.—ECHINOBRISSIDÆ, *Wright* (p. 240).

Test thin, circular, oblong, subpentagonal or clypeiform, covered with microscopic perforate or imperforate tubercles surrounded by excavated areolæ. Ambulacral areas narrow. Poriferous zones more or less petaloid, pores set at different distances apart, and united by connecting sutures. Interambulacral areas wide. Oral opening small, nearly central, pentagonal. Peristome generally lobed. Jaws absent. Apical disc small with four perforate and one imperforate genital plates; ocular plates very small. Madriporiform body extending into the centre of the disc. Anal opening in a furrow in upper margin or under surface of the single interambulacrum. Range of the family, from the Oolitic to the existing period. Five British Cretaceous genera: Catopygus, Clypeopygus, Echinobrissus, Trematopygus, Caratomus, and eight species (pp. 241—256).

Genus 16.—Catopygus, *Agassiz* (p. 240).

Test thin, oval or elongated, convex above, flat below, sides inflated, anal half much higher than oral half. Ambulacral areas narrow, petaloid above, forming a straight band on under side. Poriferous zones composed of an inner series of round pores, and an external series of elongated pores arranged in conjugate pairs; tubercles very small, numerous and scattered. Oral opening small, subcentral, pentagonal, with five prominent lobes. Apical disc small at the summit, prominent, with four perforated ovarial plates, and five microscopic ocular, the madriporiform body projecting. Anal opening small, round or oval, situated in the posterior border, at the summit of the vertical truncation of the posterior border. Spines unknown. Range of genus, from the Lower Greensand to Upper Tertiary. Three British Cretaceous species (pp. 241—246, 340).

Genus 17.—Clypeopygus, *d'Orbigny* (p. 246).

Test thin, oblong, depressed, convex above, concave below, covered with numerous small tubercles which are larger on the under side than the upper, and are placed in areal depressions. Ambulacral areas narrow and subpetaloid on upper surface, narrow below, and suddenly contracting near the peristome. Poriferous zones unequal in width from summit to base. Interambulacral area wide. Oral opening excentral nearest the anterior border. Peristome pentangular, surrounded by five rosettes of buccal pores, and separated by five prominent lobes. Apical disc small, excentral, and composed of four perforated and one imperforate genital plates, the right antero-lateral supporting the madriporiform body, which extends into the middle of the disc and forms a prominence there. A Lower Cretaceous genus. One British Cretaceous species (pp. 247, 248).

Genus 18.—ECHINOBRISSUS, *Breynius* (p. 248).

Test small, oval or subcircular, rounded anteriorly, truncated posteriorly; base slightly concave, upper surface convex; plates covered with microscopic granulations, and perforated tubercles in depressed areas. Ambulacral areas narrowly lanceolate. Oral opening small, excentral, pentagonal, lodged in an excentral depression. Apical disc small, quadrate and compact, composed of four perforated and one imperforate genital plate; the right antero-lateral supports the madreporiform body. Anal opening oval, in a groove extending from the summit to the margin. Range, from the Inferior Oolite to the existing period. Two British Cretaceous species (pp. 249—251).

Genus 19.—TREMATOPYGUS, *d'Orbigny* (p. 252).

Test thin, ovate, contracted and rounded before, more or less enlarged behind, convex above, concave on under surface. Ambulacral areas subpetaloid above, narrow below. Oral opening irregularly pentagonal, compressed obliquely from left to right, and from above downwards. Apical disc quadrate, excentral, with four perforate ovarial plates, and one imperforate plate. Madreporiform body covering the genital elements, and forming a prominence in the centre of the disc. Oculars very small. Anal opening very large, pyriform elongated above the margin and placed in a groove. One British Cretaceous species (pp. 253, 254).

Genus 20.—CARATOMUS, *Agassiz* (p. 254).

Test thin, small, ovoid or circular, rounded before, often rostrated behind; sides inflated, convex above and below. Ambulacra petaloid on upper surface, straight below. Poriferous zones with simple, equal, non-conjugate pores, disposed in pairs closely approximated at the summit, apart in the middle, and approximated at the ambitus, feebly indicated at base by lines converging around the peristome. Interambulacral zones wide, covered with large tubercles. Oral opening nearly central, always obliquely elongated. Apical disc nearly central, with four perforated ovarials and five oculars, the madreporiform body extending into the middle of the disc. Anal opening inframarginal and not visible from upper surface, transversely oblong or triangular, and sometimes placed in a rostrated development of the single interambulacrum. Genus found in the Cretaceous series of rocks. One British Cretaceous species (pp. 255—256).

Family VIII.—ECHINOLAMPIDÆ, *Wright* (p. 256).

Test thin, oval, oblong, elevated or subdiscoidal, studded on upper and under surface with small tubercles, often perforated on sunken areolæ. Ambulacral areas large, petaloidal. Poriferous zones wide; pores distant, united by sutures, and extending nearly to the margin. Oral opening small, subcentral. Peristome with five prominent lobes and well-developed petaloid concavities. Jaws absent. Apical disc very small, excentral, and composed of four perforated genital and one imperforate plate, with five oculars wedged into the circumference of the disc. Range of family, from Lower Oolites to the existing period. One British Cretaceous genus: Pygurus, with one species (pp. 256—260).

Genus 21.—Pygurus, *d'Orbigny* (p. 257).

Test large, discoidal or clypeoidal, rostrated posteriorly, furnished with small perforated tubercles on sunken areolæ. Ambulacral areas strongly petaloidal. Poriferous zones near the peristome crowded in triple oblique ranks. Oral opening pentagonal, excentral. Peristome with five lobes and bays. Apical disc small. Anal opening oval inframarginal, surrounded by a distinct area. Range of genus, from the Lower Oolites to the Upper Greensand. One British Cretaceous species (pp. 258—260).

Family IX.—SPATANGIDÆ, *d'Orbigny* (p. 260).

Test thin, oval or cordiform, covered with small perforated tubercles. Fasciole generally present. Ambulacral areas united at the summit. Anterior ambulacrum lodged in a depression which extends to the anterior border. Oral aperture anterior, bilabiate. Jaws absent. Apical disc with two or four genital pores, sometimes in proximity, sometimes apart. Ocular pores five, arranged pentagonally at the apices of the ambulacra. Anal opening posterior and supramarginal, and closed by small plates. Spines hairlike. Range of family, from the Cretaceous to the existing period. Five British Cretaceous genera: Hemiaster, Epiaster, Micraster, Echinospatagus, and Enallaster, in fifteen species (pp. 260—292).

Genus 22.—Hemiaster, *Desor* (p. 261).

Test thin, elevated, cordiform, ambulacral summit excentral and posterior. Fasciole single, circumscribing the petaloid portions of the ambulacra. The pairs of ambulacra petaloidal, unequal in length, and lodged in depressions, having large poriferous zones, with

elongated pores placed close together. The single ambulacrum in a long shallow anteal sulcus, with very narrow poriferous zones composed of small round pores disposed apart in oblique, widely separate simple pairs. Oral opening bilabiate, very excentral near the margin. Apical disc small, compact, with four perforated genital plates and five very small oculars. Anal opening oval, high up on the posterior border. Genus Cretaceous. Three British Cretaceous species (pp. 262—264).

Genus 23.—Epiaster, *d'Orbigny* (p. 265).

Test thin, oblong, more or less elevated, often cordiform, with small crenulated tubercles apart, furnished with interspaced granules. No fascioles. Antero- and postero-lateral pairs of ambulacra petaloidal and lodged in depressions. Anterior pair longer and more developed than posterior. Poriferous zones equal in each ambulacra, composed of elongated pores, shorter in the internal than the external rows. Single ambulacrum lodged in a well-defined furrow, composed of pores different from those of the antero- and postero-lateral pairs. Oral opening near the anterior border and strongly bilabiate, the inferior lip strong and prominent. Apical disc with four perforated genital and five ocular plates. Anal opening round or oval, situated at the posterior border. Genus confined to Cretaceous strata. Two British Cretaceous species (pp. 265—270).

Genus 24.—Micraster, *Agassiz* (p. 270).

Test thin, cordiform, more or less inflated. Tubercles perforated, crenulated, sparsely distributed on upper surface, larger and closer below. Fasciole subanal, forming a ring around the posterior extremity, embracing half of the upper and half of the lower part of the border. Ambulacral pairs petaloidal, closed at their extremities, the anterior exceeding the length of the posterior pair. Anterior ambulacrum in a wide, shallow furrow, indenting the border of the test. Poriferous zones equal in each ambulacra; pores oval, joined by transverse depressions. Oral opening transverse, near the border, bilabiate with prominent projecting lip. Apical disc small, central, solid, composed of four perforated ovarial and five perforated ocular plates. Madreporiform body small, located in the middle of the disc. Anal opening oval in the upper part of the border under a ridge-like projection of the dorsal surface. Spines small, acicular. Genus found in Cretaceous strata. Four British Cretaceous species (pp. 271—280, 335—340).

Genus 25.—Echinospatagus, *Breynius* (p. 280).

Test thin, cordiform, granulated, more or less inflated above, flattened below. Fasciole absent. Tubercles of various sizes, crenulated, most numerous at the anterior

border. The pairs of ambulacra petaloidal, unequal in length, large, lodged in a depression. Poriferous zones of the anterior pair longer and wider than the posterior pair. The single ambulacrum lodged in a wide, deep anteal furrow; its poriferous zones are narrow and equal, and the holes are smaller and placed closer together than the pores in the pairs. Oral opening small, subpentagonal near anterior border. Apical disc compact, composed of four finely perforated ovarial plates, and five small oculars with madreporiform body extending into the centre of the disc. Anal opening oval, placed in the upper part of the posterior border. Spines unknown. Genus found in the Cretaceous strata. Four British Cretaceous species (pp. 281—287).

Genus 26.—ENALLASTER, *d'Orbigny* (p. 288).

Test thin, cordiform, tubercles small, chiefly developed on sides and base. Ambulacral summit subcentral. Ambulacral pairs subpetaloid, unequal, and depressed. Poriferous zones in the anterior pair unequal. The posterior zones much larger and wider than the anterior zones. Single ambulacrum wider than laterals, in a wide anteal furrow with narrow poriferous zones, and pores arranged obliquely. Oral opening subpentagonal near anterior border. Apical disc small, with four perforated ovarial and five perforated ocular plates. Anal opening oval, at summit of truncated posterior border. Genus found in the Lower-Cretaceous strata. Two British Cretaceous species (pp. 288—292).

FAMILY X.—ECHINOCORIDÆ, *Wright* (p. 292).

Test thick or thin, oval, cordate or conoidal, furnished with irregular small perforated tubercles. Sometimes a marginal fasciole. Ambulacral areas equal, narrowly lanceolate, converging to the vertex. Poriferous zones narrow; pores disposed in pairs at a distance apart. Oral opening transversely oblong, often bilabiate near the anterior border. Apical disc small or large, narrow and elongated, having four perforated and one unperforated ovarial plate with five perforated oculars. Anal opening round, marginal, or supra-marginal. Spines small. Range of family from the Lower Cretaceous to the existing period. Four genera: CARDIASTER, INFULASTER, HOLASTER, ECHINOCORYS, with sixteen species (pp. 293—334).

Genus 27.—CARDIASTER, *Forbes* (p. 293).

Test thin, cordiform, upper surface convex, anteal furrow well-marked with angulated borders. Tubercles perforated, raised upon crenulated bosses and surrounded by areolæ. A fasciole passing beneath the anal opening and continued on the sides. Oral opening

near the margin. Apical disc elongated, composed of four perforated genital and five perforated ocular plates. Genus found in the Cretaceous strata. Seven British Cretaceous species (pp. 293—304, 325—327).

Genus 28.—INFULASTER, *Hagenow* (p. 305).

Test thin, narrow, oblong, ovato-cordate. Anterior half very much elevated, rising into a prominent vertex. Anteal furrow narrow, deep, directed obliquely downwards and backwards with angular borders. Plates covered with very small granules, and with a few primary tubercles near vertex, and at sides and centre of under surface. Sur-anal fasciole present. Oral opening transverse near furrow. Anal opening oval, high up on truncated border. Genus found in the Cretaceous strata. Two British Cretaceous species (pp. 305—308).

Genus 29.—HOLASTER, *Agassiz* (p. 309).

Test thin, oval, cordiform, convex above, flat below, covered with granulations and a few tubercles irregularly arranged. Pairs of antero- and postero-lateral ambulacral areas lanceolate, widely apart above, joined below. Poriferous zones with elongated pores in single pairs. Single anterior ambulacrum lodged in a shallow central furrow with minute pores. Ambulacral summit central or subcentral. No fasciole. Oral aperture transversely oval and perfectly bilabiate, near anterior border in a slight depression. Apical disc elongated with four perforated ovarial plates and five perforated oculars. Genital plates disposed in pairs, the anterior being separated from the posterior by a pair of ocular plates. Anal opening oval, low down near base. Range of genus, from Middle Cretaceous to Middle Tertiary. Six British Cretaceous species (pp. 310—324).

Genus 30.—ECHINOCORYS, *Breynius* (p. 327).

Test thin, more or less oval, elevated, helmet shaped, convex or conoidal above, flat below. Ambulacral areas identical, radiating from summit. Pores round, in single pairs, set obliquely apart in the middle of the ambulacral plates and forming two rows in each area. Oral opening transversely oval, bilabiate near border. Apical disc elongated, formed of four ovarial and five ocular plates. The two pairs of ovarial plates separated by a pair of oculars. Anal opening small, oval in vertical direction, marginal or infra-marginal. Genus found in Upper Cretaceous strata. One British Cretaceous species (pp. 328—334).

APPENDIX II.

RANGE IN GEOLOGICAL TIME OF THE BRITISH CRETACEOUS ECHINOIDEA.

	Upper Chalk.	Medial Chalk.	Chalk Marl.	Chloritic Marl.	Upper Greensand.	Blackdown Beds.	Red Chalk.	Gault.	Lower Greensand.	Farringdon Sponge Gravels.
ECHINOIDEA ENDOCYCLICA.										
Family I. CIDARIDÆ, *Wright.*										
Genus 1. Cidaris	×	...	×	...	×	...	×	×	...	×
„ II. DIADEMADÆ, *Wright.*										
Genus 2. Pseudodiadema, *Desor.*	×	...	×	×	×	...	×	×	×	×
„ 3. Pedinopsis, *Cotteau*	...	...	...	×						
„ 4. Echinocyphus, *Cotteau*	...	...	×	...	×					
„ 5. Glyphocyphus, *Haime*	...	...	×							
„ 6. Cyphosoma, *Agassiz*	×	...	×							
„ III. SALENIADÆ, *Wright.*										
Genus 7. Peltastes, *Agassiz*	...	...	×	...	×	...	×	...	×	×
„ 8. Goniophorus, *Agassiz*	...	...	...	...	×					
„ 9. Salenia, *Gray*	×	×	×	...	×					
„ 10. Cottaldia, *Desor*	...	...	...	...	×					
„ IV. ECHINOTHURIDÆ, *Wyv. Thomson.*										
Genus 11. Echinothuria, *Woodward*	×									
ECHINOIDEA EXOCYCLICA.										
„ V. ECHINOCONIDÆ, *Wright.*										
Genus 12. Discoidea, *Klein*	×	×	×	...	×	...	×			
„ 13. Echinoconus, *Breynius*	×	×	×	×	×					
„ 14. Holectypus, *Desor*	...	...	...	×						
„ VI. ECHINONIDÆ, *Wright.*										
Genus 15. Pyrina, *Desmoulins*	...	...	×	×	×					
„ VII. ECHINOBRISSIDÆ, *Wright.*										
Genus 16. Catopygus, *Agassiz*	...	...	×	×	×	...	...	...	×	
„ 17. Clypeopygus, *A. d'Orbigny*	...	...	...	...	...	...	...	...	×	
„ 18. Echinobrissus, *Breynius*	...	...	...	×	×	×				
„ 19. Trematopygus, *A. d'Orbigny*	...	...	...	...	...	...	...	...	...	×
„ 20. Caratomus, *Agassiz*	...	...	...	...	×					
„ VIII. ECHINOLAMPIDÆ, *Wright.*										
Genus 21. Pygurus, *d'Orbigny*	...	...	...	...	×					
„ IX. SPATANGIDÆ, *d'Orbigny.*										
Genus 22. Hemiaster, *Desor.*	...	...	×	...	...	...	...	×		
„ 23. Epiaster, *d'Orbigny*	×	...	...	...	×					
„ 24. Micraster, *Agassiz* ..	×	×								
„ 25. Echinospatagus, *Breynius*	...	...	...	...	×	×	...	...	×	
„ 26. Enallaster, *d'Orbigny*	...	...	...	...	...	×	...	...	×	
„ X. ECHINOCORIDÆ, *Wright.*										
Genus 27. Cardiaster, *Forbes*	×	×	...	...	×	×	...	...	×	
„ 28. Infulaster, *von Hagenow*	×	×								
„ 29. Holaster, *Agassiz*	×	...	×	×	×	...	×			
„ 30. Echinocorys, *Breynius*	×									

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TO THE

FAMILIES, GENERA, AND SPECIES OF THE BRITISH CRETACEOUS ECHINOIDEA.

The synonyms are printed in Italics.

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„ (pars), Agassiz; *see* Glyphocyphus.
„ granulosa, Agassiz; *see* Cottaldia Benettiæ.
„ *radiata*, Roemer; *see* Glyphocyphus radiatus.
ANANCHYTES, Lamarck; *see* ECHINOCORYS.
„ *analis*, Roemer; *see* Cardiaster pillula.
„ *carinatus*, Defrance; *see* Echinocorys vulgaris.
„ *conica*, Agassiz; *see* Echinocorys vulgaris.
„ *conoideus*, Goldfuss; *see* Echinocorys vulgaris.
„ *cordata*, Lamarck; *see* Cardiaster ananchytes.
„ *crassissima*, Agassiz; *see* Echinocorys vulgaris.
„ *Eudesii*, Sorignet; *see* Echinocorys vulgaris.
„ *gibba*, Lamarck; *see* Echinocorys vulgaris.
„ *Gravesii*, Agassiz and Desor.; *see* Echinocorys vulgaris.
„ *hemisphærica*, Brongniart; *see* Echinocorys vulgaris.
„ *ovatus*, Lamarck; *see* Echinocorys vulgaris.
„ *pillula*, Lamarck; *see* Cardiaster pillula.
„ *pustulosa*, Lamarck; *see* Echinocorys vulgaris.
„ *pyramidatus*, Portlock; *see* Echinocorys vulgaris.
„ *rustica*, Defrance; *see* Echinocorys vulgaris.
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„ *striatus*, Goldfuss; *see* Echinocorys vulgaris.

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„ *coronalis*, Gmelin; *see* Cyphosoma corollare.
„ *cretosa*, Morris; *see* Cidaris sceptrifera.
„ „ Mantell; *see* Cidaris subvesiculosa.
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„ cor-anguinum, *Gmelin; see* Micraster cor-anguinum.
„ *corollaris*, Desmoulins; *see* Cyphosoma corollare.
„ *granulosus*, Dujardin; *see* Cyphosoma granulosum.
„ *granulosus*, Münster; *see* Cottaldia Benettiæ.
„ *Koenigi*, Fleming; *see* Cyphosoma Koenigi.
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„ „ (pars), Desmoulins; *see* Cyphosoma granulosum.
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„ *Rothomagensis*, Agassiz; *see* Echinoconus castanea.
„ *rotularis*, Lamarck; *see* Discoidea subuculus.
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„ *Morrisii*, Forbes; *see* Echinobrissus Morrisii.
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„ *pillula*, Mantell ; *see* Cardiaster pillula.
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„ *Collignii*, Sismonda ; *see* Echinospatagus Collignii.

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PLATE I.

Cidaris from the Gault and Grey Chalk.

CIDARIS CARTERI, *Forbes*, 1854.

From the Grey Chalk.

FIG.

1 *a*. Upper surface, showing the disc, natural size. From the collection of James Carter, Esq. P. 39.

b. Lateral view of the same, showing the height of the test and the prominence of the discal elements.

c. A single inter-ambulacral plate, with a portion of the ambulacral area and poriferous zones, magnified.

d. Apical disc, with the ovarial and ocular plates, magnified.

e. Portion of a spine, magnified.

f. A small ambulacral spine, magnified.

CIDARIS GAULTINA, *Forbes*, 1854.

From the Gault.

2 *a*. Test and spines, *in situ*. British Museum. P. 36.

b. Inter-ambulacral plate, magnified two and a half times.

c. One large primary spine, natural size.

d. A portion of ditto, near the base, magnified twice.

e. Stellate terminal portion of a primary spine, magnified.

3 *a*. A primary spine, natural size.

b. The same, magnified twice.

4 *a*. A primary spine, with expanded stem.

b. The same, magnified twice.

c. A view of the terminal portion.

C R Bone del et lith

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PLATE II.

Cidaris from the Upper Greensand and Grey Chalk.

Cidaris Bowerbankii, *Forbes*, 1850.

From the Grey Chalk.

Fig.

1 *a*. Test and spines, *in situ*, natural size, belonging to Dr. Bowerbank, F.R.S. P. 45.
b. An inter-ambulacral spine, magnified three times.
c. The head, milled ring, and neck, highly magnified.
d. A small ambulacral spine, highly magnified.

Cidaris velifera, *Bronn*, 1857.

From the Upper Greensand.

2 *a*. A lateral view of the test, natural size, in the collection of W. Cunnington, Esq., F.G.S. P. 37.
b. Basal portion of the same, magnified twice.
c. Dorsal portion of the same, magnified twice.
d. Lateral view of the same, magnified twice.
e. Inter-ambulacral plate, a portion of the ambulacra and poriferous zones, magnified five times.
f. A lateral view of a primary tubercle with its circle of areolar granules, magnified.

3 *a*. One of the inter-ambulacral spines, natural size.
b. The same spine, magnified twice.

4 *a*. Cidaris velifera, a portion of the test and spines, *in situ*, natural size. This unique specimen is in the cabinet of Mr. W. Cunnington.
b. The head of a spine, with its milled ring, highly magnified.

Cidaris vesiculosa, *Goldfuss*, 1826.

From the Upper Greensand and Grey Chalk.

5 *a*. Upper surface of the test, natural size. This specimen from the Upper Greensand is in the possession of W. Cunnington, Esq., F.G.S. P. 41.
b. Basal portion of the same test, natural size.
c. Lateral view of the same test, natural size.
d. An inter-ambulacral plate, with ambulacra and poriferous zones, magnified three times.

Cidaris Farringdonensis, *Wright*, 1864.

From the Lower Greensand.

6, 7. Single inter-ambulacral plates from the Sponge-Gravel, near Farringdon, magnified two diameters. Museum of Royal School of Mines.

8 *a*, *b*, *c*. Different inter-ambulacral spines of this species. Museum of Royal School of Mines.
c, *a*. Basal portion of one magnified three times.

Bone del. et lith

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PLATE III.

Cidaris from the Red and Grey Chalk.

CIDARIS VESICULOSA, *Goldfuss*, 1826.

From the Grey Chalk.

FIG.

1 *a*. Under surface of a large test, Grey Chalk, Dover, natural size. British Museum. P. 41.

b. The under surface of the same test, natural size.

c. A lateral view of the same test, natural size.

d. One inter-ambulacral plate, with a portion of the ambulacra and poriferous zones, magnified three times.

e. A primary tubercle, magnified.

3 *a*. Test of CIDARIS VESICULOSA (?), from the Red Chalk, under surface, natural size. In the collection of C. B. Rose, Esq., F.G.S.

b. Upper surface of the same test, natural size.

4. Inter-ambulacral spine from the Red Chalk. In the collection of C. B. Rose, Esq., F.G.S.

5 *a*. Ditto ditto ditto.

b. Portion of the same, magnified three times.

CIDARIS DISSIMILIS, *Forbes*, 1854.

From the Lower Chalk.

2 *a*. Upper surface of the test, natural size. In the collection of Rev. T. Wiltshire, F.G.S. P. 46.

b. Under surface of the same test, natural size.

c. Lateral view of the same test, natural size.

d. Inter-ambulacral plate, ambulacra, and poriferous zones, magnified three times.

e. A single tubercle, magnified.

f. Portion of an inter-ambulacral spine, magnified.

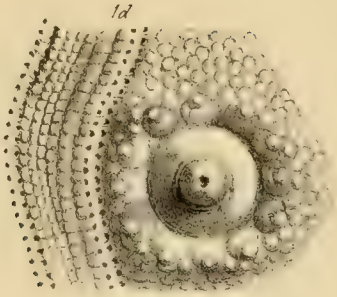
g. An ambulacral spine, greatly magnified.

1a

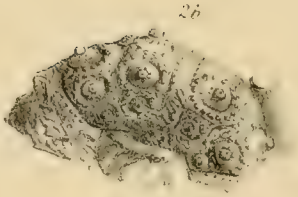
1c

1b

1e


1d

2a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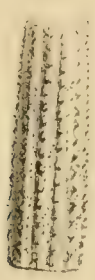
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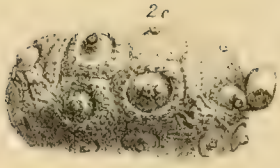
2g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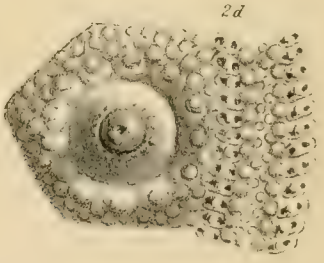
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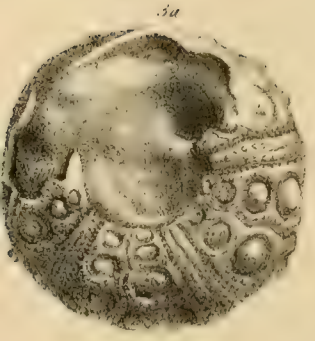
2e


3a

3b

4

5b

5a

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PLATE III *a*.

Cidaris dissimilis, *Forbes*, 1854.

From the Grey Chalk.

Fig.

1 *a*. Upper surface of the test, with spines attached, natural size, from the late Mr. Taylor's collection, now in the British Museum, p. 46.

b. Portion of an inter-ambulacral spine of this species, magnified several diameters. British Museum.

2 *a*. Test and spines, upper surface, natural size, belonging to the Rev. T. Wiltshire, F.G.S.

b. Test and spines, under surface, natural size, ditto, ditto.

c. Penultimate inter-ambulacral plate from the upper part of the column, showing the obsolete tubercle and areola.

d. Inter-ambulacral spine, natural size.

e. Portion of the stem, neck, and head, of the same spine, magnified several times.

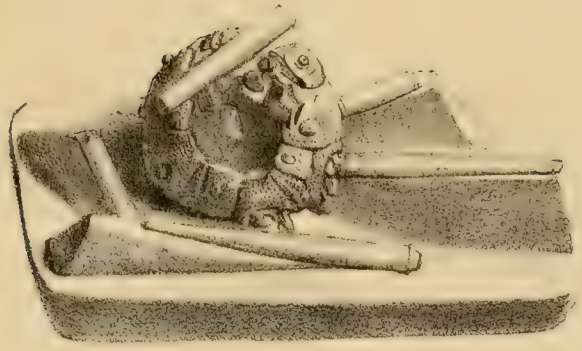
f. Portion of another smaller spine, magnified.

g. Ambulacral spines, natural size and magnified.

3 & 4. Inter-ambulacral spines, natural size, Rev. T. Wiltshire's cabinet.

5. A small test and spine, natural size, ditto, ditto.

1a



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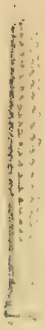

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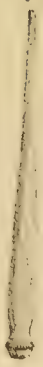
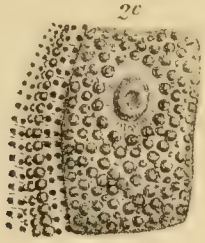


5

2c



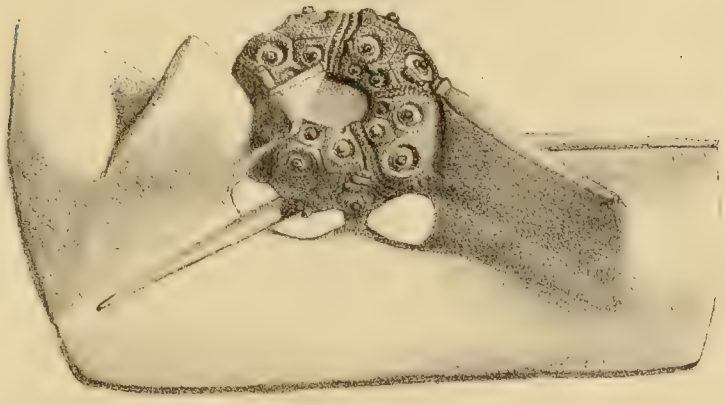
3

4

2g

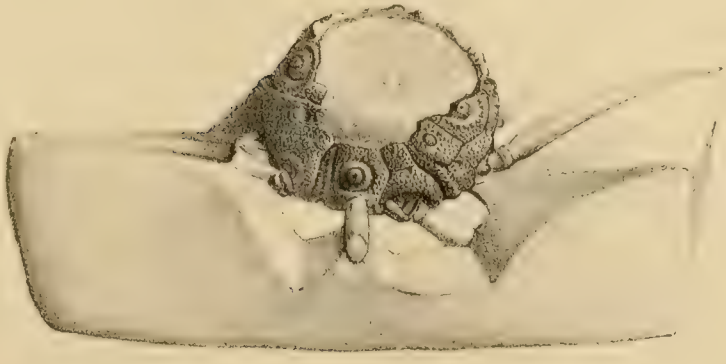
1c

2b

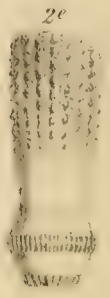


1b

2a



2e



C.R.Bone del et lith.

W.West. imp.

PLATE IV.

Cidaris clavigera, *König*, 1822.

From the White Chalk.

Fig.

1 *a*. Two tests, with spines, in one block of chalk, natural size. From the late Mr. Taylor's collection, now in the cabinet of Dr. Bowerbank, F.R.S. P. 48.

b. Inter-ambulacral plate, ambulacra, and poriferous zones, magnified three diameters.

c. A large tubercle, and circle of areolar granules, magnified.

2. The apical disc, with the ovarial, ocular, and anal plates *in situ*, magnified two diameters.

3 *a*. A large inter-ambulacral spine of a typical form, natural size.

b. The same, magnified two diameters.

c. A portion of the neck of the same, magnified three diameters.

4 *a*. A large spine of an abnormal form, natural size.

b. A large spine of an abnormal form, magnified two and a half diameters.

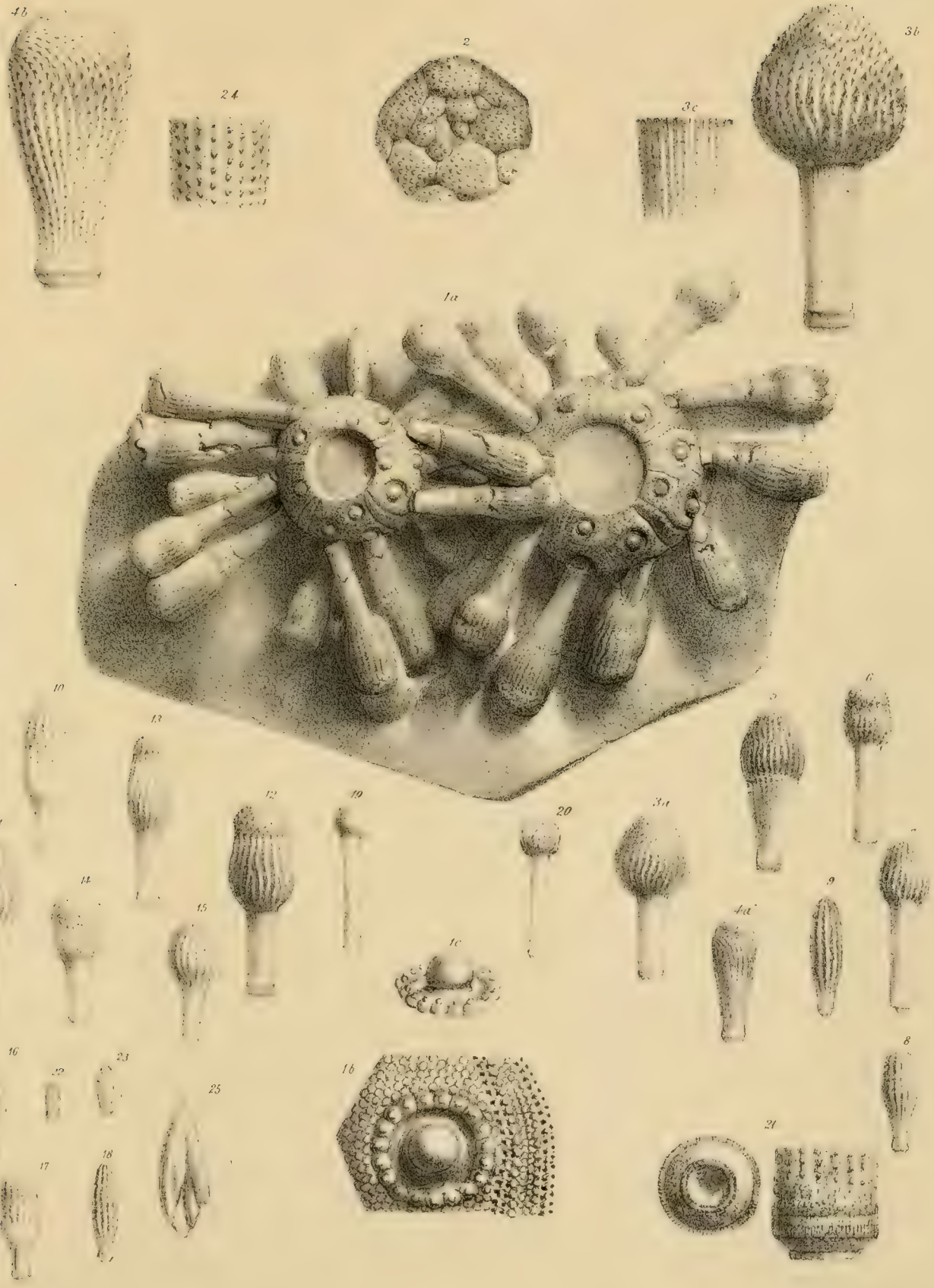
c. A portion of the neck of the same, magnified three diameters.

5—20. Different forms of inter-ambulacral spines, from a series in the collection of Dr. Bowerbank, F.R.S.

21. The neck, milled ring, head, and acetabulum of the specimen figured at 3 *a*, magnified four diameters.

22. A small ambulacral spine, highly magnified.

23. Another ambulacral spine, highly magnified.



C.R.Bone, del et lith

Printed by Hullmandel & Walton

PLATE V.

Cidaris clavigera, *König*, 1822.

From the White Chalk.

Fig.

1. Test, with dental organs and spines, natural size. From Mr. Taylor's collection, now in the British Museum. P. 48.

2 *a*. Lateral view of a fine test, natural size. British Museum.
b. The under surface of the same, natural size.

3. The apical disc, showing the ovarial, ocular, anal plates, and madreporiform body, magnified two and a half diameters. British Museum.

4. A portion of the peristomal membrane and oral plates, with part of the dental organs, magnified two and a half diameters. British Museum.

5 *a*. An abnormal inter-ambulacral spine, natural size. British Museum.
b. The same, magnified, to show the position and form of the canals passing through the stem.

6. An abnormal spine, with summit excavated, natural size. This specimen belongs to the Rev. T. Wiltshire.

7—14. Varieties of large inter-ambulacral spines, belonging to the British Museum, natural size. British Museum.

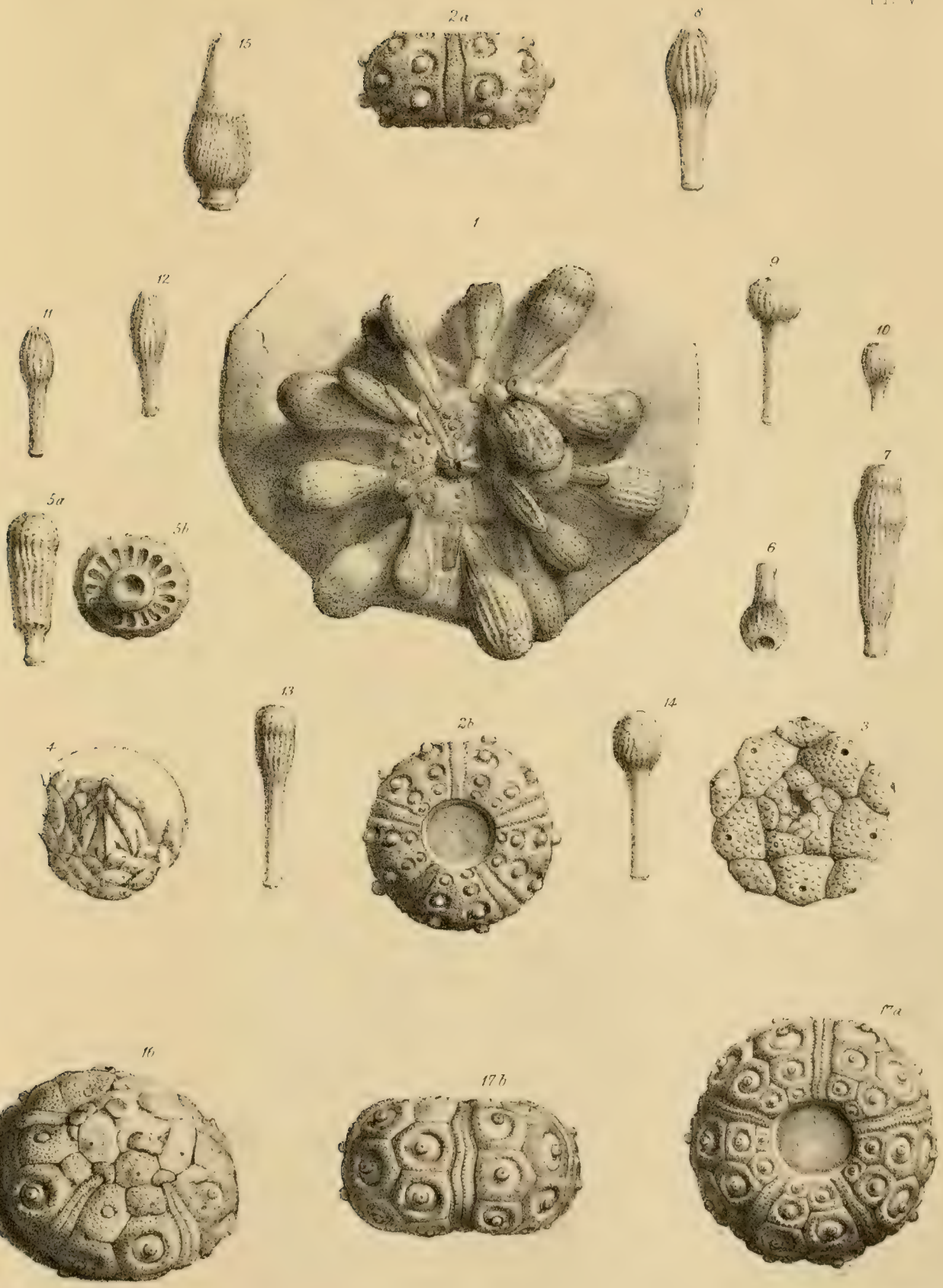
15. A remarkable abnormal form, with an enlarged neck and conical stem and apex, natural size. British Museum.

Cidaris sceptrifera, *Mantell*, 1822.

From the White Chalk.

16. Upper surface of a fine test, natural size, with the apical disc *in situ*. This specimen belongs to Dr. Bowerbank's collection. P. 54.

17 *a*. Under surface of the same, natural size.
b. Lateral view of the same.



C.R.Bone, del et lith.

Printed by Hullmandel & Walton

PLATE VI.

Cidaris sceptrifera, *Mantell*, 1822.

From the White Chalk.

Fig.

1 *a*. Upper surface of the test, natural size. This magnificent specimen belongs to the British Museum. P. 54.

b. Under surface of the same, natural size.

c. Lateral view of the same, natural size.

d. Inter-ambulacral plate, ambulacra, and poriferous zones, magnified three diameters.

e. The uppermost plate of an inter-ambulacral column, showing the curious rudimentary tubercles, and areola thereon, magnified two diameters.

f. The uppermost plate of the adjoining column, magnified two diameters.

g. A portion of the apical disc, consisting of one ovarial, two ocular plates, and three anal plates, magnified two diameters. The entire disc is seen *in situ*, in fig. 1 *a*.

h. Three anal plates, magnified two diameters.

2. Test with spines, natural size. This specimen belongs to the Museum of the Royal School of Mines.

3 *a*. Spine, type form, natural size.

b. The upper part of the stem, magnified three diameters.

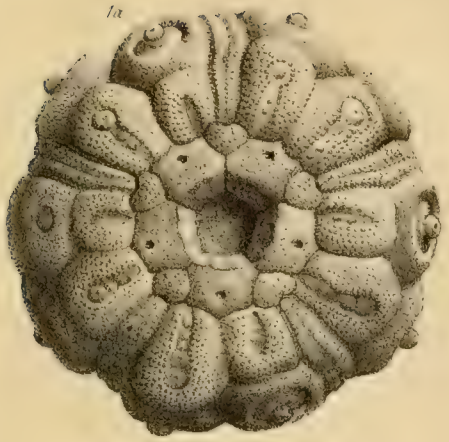
c. The stellate form of the terminal extremity, magnified three diameters.

4 *a*. Spine, type form, natural size.

b. The head, neck, and milled ring of the same, magnified three diameters.

5 *a*, *b*. Another spine, natural size.

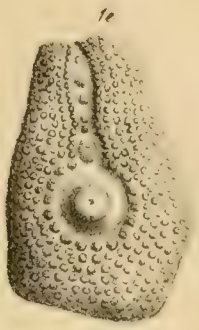
6. A variety. Specimens 3, 4, 5, and 6, belong to the British Museum.

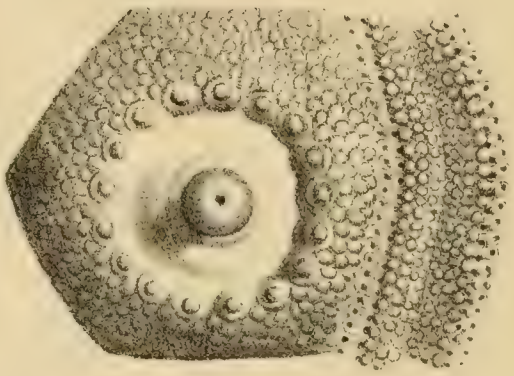

1a

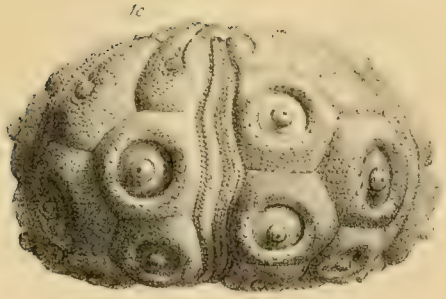
1h

1g

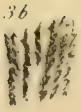
1b


1e


1d


1c

1f

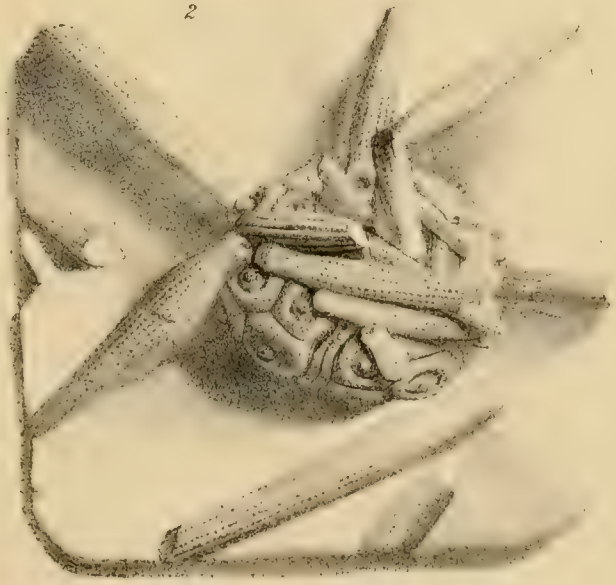

3b

3c

4b

3a

4a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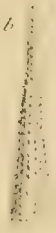

5b

5a

6

C R Bone del. et lith.

Printed by Hullmandel & Walton

PLATE VII.

Cidaris sceptrifera, *Mantell*, 1822.

From the White Chalk..

Fig.

1 *a*. Test, dental organs, and spines, *in situ*, natural size. From the late Mr. Taylor's collection, now in the Museum of the Royal School of Mines. P. 54.

b. Dental apparatus and teeth, magnified two diameters.

c. Ambulacral spine, greatly magnified.

2. Spine of *C. sceptrifera*, variety. From the cabinet of the Rev. T. Wiltshire, F.G.S.

Cidaris perornata, *Forbes*, 1850.

From the White Chalk.

3 *a*. Lateral view of the test, natural size. In the British Museum. P. 62.

b. Under surface of the same, natural size.

c. Interambulacral plate, ambulacra, and poriferous zones, magnified three diameters.

d. Lateral view of a primary tubercle, magnified.

4 *a*. Inter-ambulacral spine, natural size. Museum of the Royal School of Mines.

b. Stem, neck, head, and milled ring, magnified three diameters.

c. A portion of the stem, magnified six diameters, to show the spiny ridges and the longitudinal lines in the valleys.

1a

1b

1c

2

3c

3d

4b

4a

3b

4c

3a

C.R.Bone, del et lith.

W West, imp

PLATE VII *a*.

Cidaris sceptrifera, *Mantell*, 1822.

From the White Chalk.

Fig.

1 *a*. Test and spines, *C. sceptrifera*, var. *filosa*, from the White Chalk of Gravesend, natural size, presented to the British Museum by the Rev. Norman Glass, F.G.S. P. 54.

b. Inter-ambulacral plate, ambulacra, and poriferous zones, magnified three diameters.

c. A thickened variety of spine, magnified two diameters.

3. Spine of *C. sceptrifera*, var. *filosa*, belonging to the Rev. Thos. Wiltshire, F.G.S.

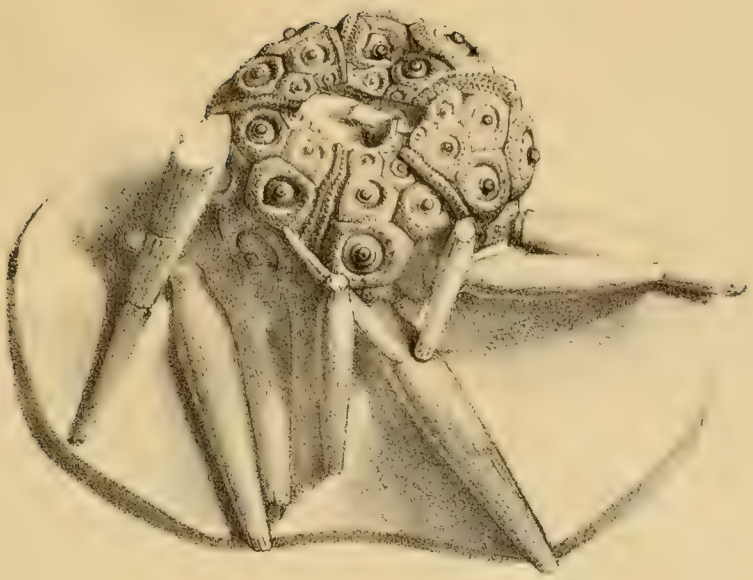
Cidaris perornata, *Forbes*, 1850.

From the White Chalk.

2 *a*. Under surface of a large *C. perornata*, restored from the Rev. Thos. Wiltshire's specimen, now in his cabinet. P. 62.

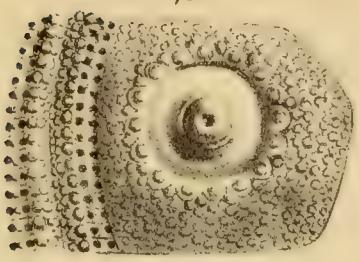
b. Lateral view of the same.

1a



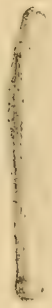
1c

1b

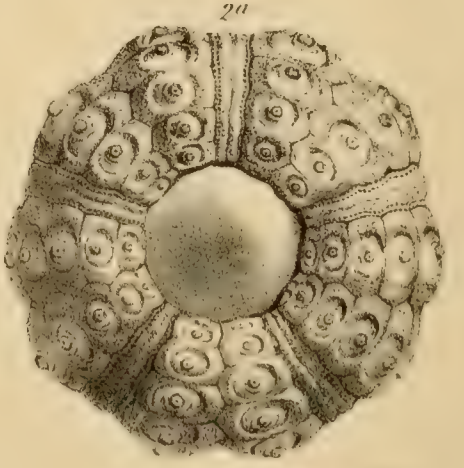


1d

3



2a



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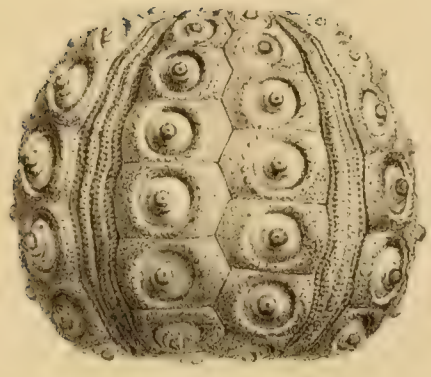


C.R.Bone del. et lith.

W.West imp.

PLATE VIII.

Cidaris Merceyi, *Cotteau.*

From the White Chalk.

Fig.

1 *a*. Under surface of the test, natural size. In the possession of Dr. Bowerbank, F.R.S. P. 60.

b. Lateral view of the same, natural size.

c. Inter-ambulacral plate, ambulacra, and poriferous zones, magnified three diameters.

d. A lateral view of the same plate, magnified three diameters.

e. A penultimate plate, from the upper part of one of the inter-ambulacral columns, showing the small rudimentary tubercle and areolæ, magnified three diameters.

f. A small inter-ambulacral plate, near the peristome, magnified three diameters.

g. A portion of an ambulacral area, and poriferous zones, magnified five diameters.

2 *a*. Inter-ambulacral spine, natural size.

b. A portion of the stem, magnified two and a half diameters.

c. The head, neck, and part of the stem, magnified two and a half diameters.

3. A small inter-ambulacral spine, natural size.

Cidaris subvesiculosa, *d'Orbigny.*

From the White Chalk.

4 *a*. Upper part of the test, and apical disc with one spine, *in situ*, natural size. From the collection of Dr. Bowerbank, F.R.S. P. 57.

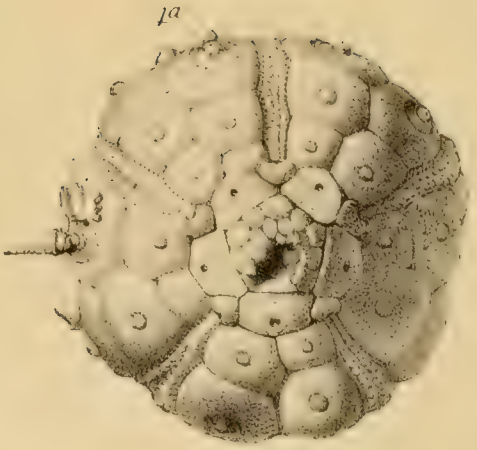
b. A plan of the apical disc, showing the parts that are absent in the preceding figure.

5. Lateral view of a smaller test. Dr. Bowerbank's collection.

6. An ambulacral spine, highly magnified.

5

6


1a

1b

19

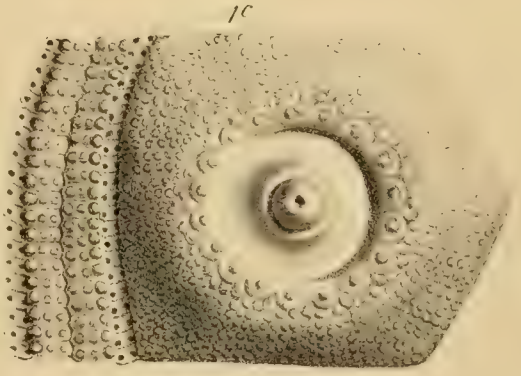
3

2a

1f

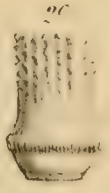
1d

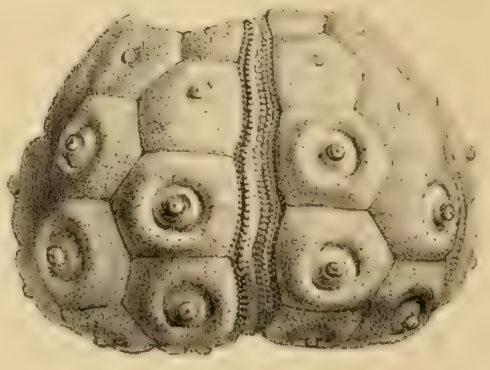
1c


1c

1a

2b


2c


1b

C R. Bone, del.

W West, imp.

PLATE IX.

CIDARIS HIRUDO, *Sorignet*, 1850.

From the White Chalk.

Fig. 1 *a*. Test and spines natural size in the Collection of Henry Willett, Esq., F.G.S. (P. 64.)

1 *b*. Lateral view of the same test, natural size.

1 *c*. Small spine from the ambulacral tubercles, magnified three diameters.

Fig. 2 *a*. Upper surface of a test, natural size, belonging to the British Museum.

2 *b*. Interambulacral plate, ambulacral area and poriferous zones of the same, magnified three diameters.

2 *c*. Apical disc and anal plates of the same, natural size.

2 *d*. One ovarial and two ocular plates of the same, magnified twice.

Fig. 3. Under surface of another test, natural size, belonging to the British Museum.

Fig. 4 *a*. Primary spine, natural size, belonging to the British Museum.

4 *b*. Lower portion of the same, magnified three diameters.

4 *c*. Upper portion showing its stellate termination, magnified three diameters.

Fig. 5. Primary spine, magnified three times, in the collection of Rev. T. Wiltshire, F.G.S.

1a

2d

2c

2b

3

2a

5.

1c

4b

1b

4c

4a

C. R. Pope, del. et lith.

Printed by W. West

PLATE X.

Cidaris hirudo, *Sorignet*, 1850.

From the White Chalk.

Fig. 1 *a*. Test the natural size, with spines attached, in the collection of Professor Tennant, F.G.S. (P. 64.)

1 *b*. Primary spine of the same, magnified twice.

Fig. 2. Lateral view of another specimen belonging to the British Museum.

Fig. 3 *a*. Upper surface of a small specimen belonging to the British Museum.

3 *b*. Under surface of a small specimen belonging to the British Museum.

3 *c*. Lateral view of a small specimen belonging to the British Museum.

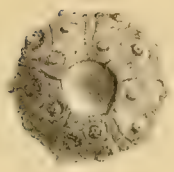
3 *d*. Interambulacral plate, ambulacral area zones of the same, magnified three times.

Fig. 4. Primary spine magnified twice, in the cabinet of the Rev. T. Wiltshire, F.G.S.

Fig. 5. Primary spine magnified twice, in the cabinet of the Rev. T. Wiltshire, F.G.S.

Fig. 6. Primary spine magnified twice, in the cabinet of the Rev. T. Wiltshire, F.G.S.

3c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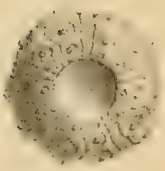
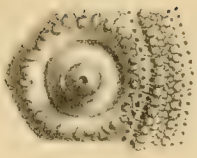
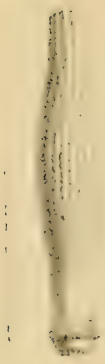
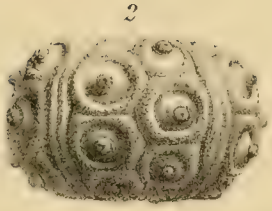

3b


3d

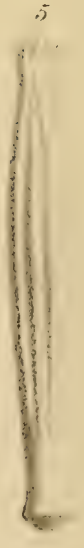

1b

1


2

6

1a


5

C R Bone del et lith

W West imp

PLATE XI.

CIDARIS SERRIFERA, *Forbes*, 1850.

From the White Chalk.

FIG.

1 *a*. Test and spines, natural size. Collection of Henry Willett, Esq., F.G.S. P. 51.

b. Under surface of the same test, natural size.

c. Lateral view of the same, natural size.

d. Inter-ambulacral plate, ambulacra, and poriferous zones, magnified three diameters.

e. Inter-ambulacral spine, natural size.

f. Stem, neck, and head of the same, magnified three diameters.

g. Portion of the stem, highly magnified, to show the serrated spines and intervening sulci. In the cabinet of Dr. Wright.

h. Ambulacral spine, highly magnified.

2. Portion of a spine of *C. serrifera*, magnified. Collection of Professor Tennant, F.G.S.

3 *a*. Spines of Cidaris. British Museum.

b. One of the spines, magnified two diameters.

4. CIDARIS DIXONI, *Cotteau*, 1862. Inter-ambulacral spine, natural size. From the Grey Chalk of Dover. Collection of Henry Willett, Esq., F.G.S.

a. A section of another specimen, to show the cavity in the stem.

5. CIDARIS PLERACANTHA, *Agassiz*. Spine, natural size. British Museum.

6. Spines of Cidaris, natural size, and magnified twice. British Museum.

C R Bone del et lith

W West imp.

PLATE XII.

From the White Chalk.

Fig. 1 *a*. Test and spines of *Cidaris intermedia*, Wiltsh., natural size. Collection of Rev. Thomas Wiltshire, F.G.S. (P. 69).

b. Spine belonging to the tubercle, the third from the peristome, magnified.

Fig. 2. Spine of *Cidaris hirudo* (?), magnified.

Fig. 4. Unusual form of spine, probably belonging to *C. sceptrifera*, magnified. Collection of Rev. Thomas Wiltshire, F.G.S.

From the Lower Chalk.

Fig. 3 *a*. Spine of *Cidaris dissimilis*, Forb., natural size. Collection of Rev. Thomas Wiltshire, F.G.S. (P. 46)

b. Head and spine of same magnified.

Fig. 5. Spine of *Cidaris pleracantha*, Agass., natural size. Collection of J. R. Capron, Esq., F.G.S. (P. 67.)

From the Upper Greensand.

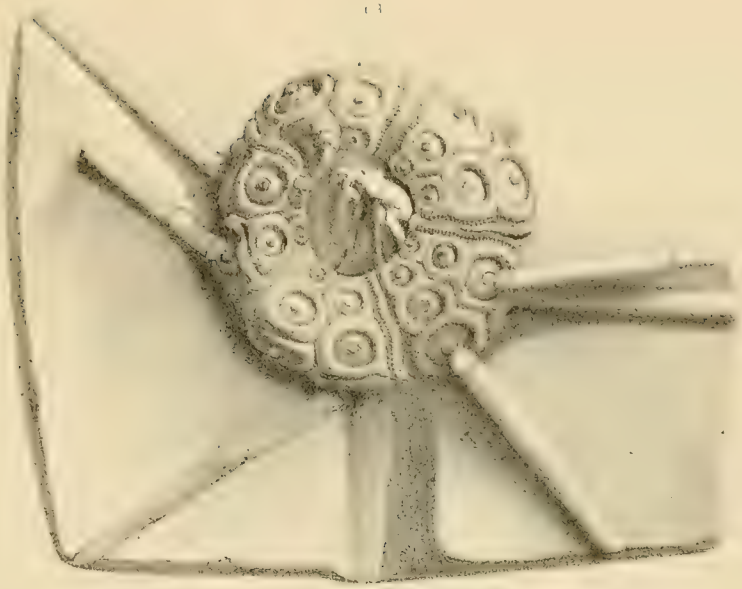
Fig. 6. Spine of *C. Dixoni*, natural size. Collection of Rev. Thomas Wiltshire, F.G.S. (P. 67.)

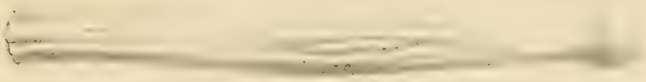
From the Red Chalk.

Figs. 7, 8, 9. Spines of *Cidaris*, natural size, from Hunstanton. Cabinet of Rev. Thomas Wiltshire, F.G.S. (P. 79.)

Fig. 10 *a*. Spines of *Cidaris*, natural size, from Speeton. (P. 79.)

Fig. *b*. The same, magnified.





C R Bone del et lith

M & N Hanhart imp r

PLATE XIII.

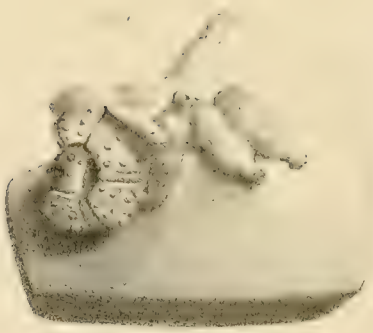
From the White Chalk.

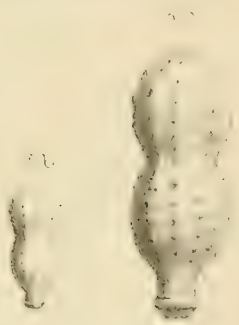
CIDARIS CLAVIGERA, *König*, 1822.

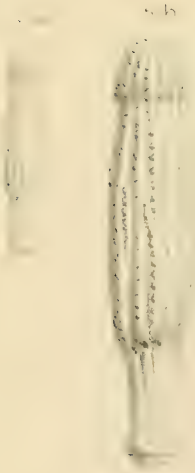
Fig. 1 *a*. Test and spines, natural size. (P. 71.)
b. Spine of same, magnified.
Fig. 2. Spine of same, natural size.
Fig. 3 *a*. Test and spines, natural size. (P. 71.)
b. Spine of same, natural size.
c. Spine of same, magnified.
Fig. 4 *a*. Test and spines, natural size. (P. 71.)
b. Spine of same, magnified.
Fig. 5 *a*. Spine of *C. clavigera*, of elongate form, natural size. (P. 71.)
b. The same, magnified.

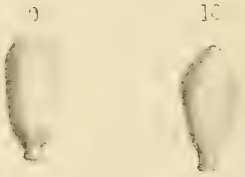
From the Lower Chalk.

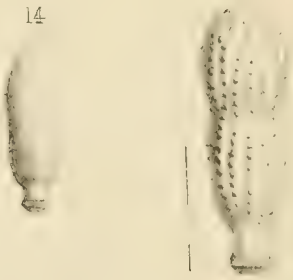
Fig. 6 *a*. Plates of *Cidaris dissimiles*, Forb. (P. 46.)
b. One of the plates, magnified. All the above are from the Cabinet of the Rev. Thomas Wiltshire, F.G.S.
Fig. 7 *a*. Spine of *Cidaris pleracantha?* natural size. Collection of J. R. Capron, Esq., F.G.S.
b. The same, magnified. (P. 67.)
Figs. 8, 9, 10. Spines of *Cidaris Bowerbankii*, Forb. Collection of Rev. T. Wiltshire, F.G.S. (P. 77.)
Fig. 11. Do. do. Do. J. R. Capron, Esq., F.G.S.
Fig. 13 *a*. Do. natural size. Cabinet of Rev. Thomas Wiltshire, F.G.S.
b. Head and neck of same, magnified.
Fig. 14. Spine of same, natural size. Cabinet of Rev. Thomas Wiltshire, F.G.S.

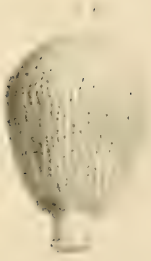


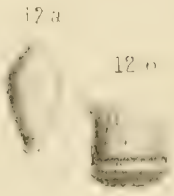












M & N. Hanhart. imp.

PLATE XIV.

From the Chloritic Marl.

Fig. 1 *a*. PEDINOPSIS WIESTII, *Wright*, upper surface of the test, natural size. In the collection of Mr. Wiest.

1 *b*. „ „ under surface, natural size.

1 *c*. „ „ lateral view, natural size.

1 *d*. Ambulacral area, poriferous zones, and interambulacra, magnified four diameters

1 *e*. Base of an ambulacral area, showing the disposition of the pores, × four times.

Fig. 2 *a*. Fistulous spine of a Diadema from the White Chalk, × six times. British Museum.

2 *b*. Do. do. do. × six times.

2 *c*. Do. do. do. × six times.

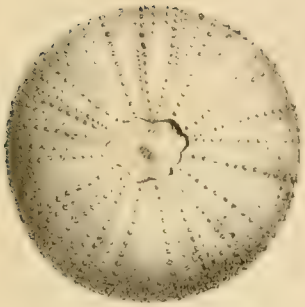
2 *d*, *e*. Do. do. do. × six times.

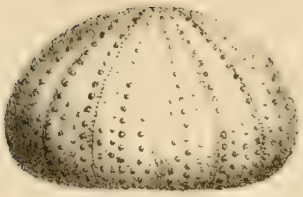
From the Lower Greensand.

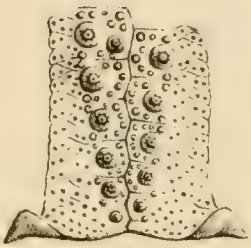
Fig. 3 *a*. PSEUDODIADEMA ROTULARE, *Agassiz*, base magnified one half. In the Cabinet of Dr. Wright, F.R.S.E. (P. 87.)

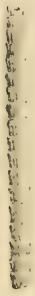
3 *b*. „ „ lateral view do. do.

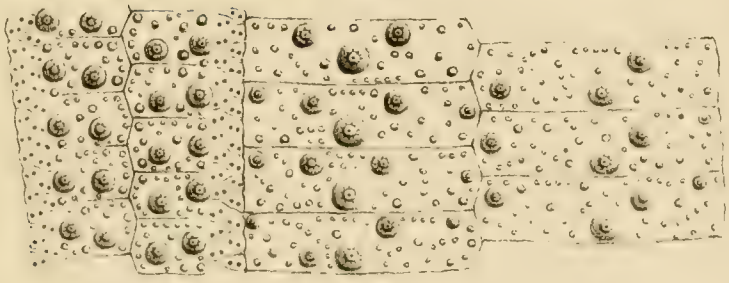
3 *c*. „ „ segment of the base, do. four times.

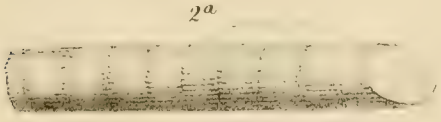


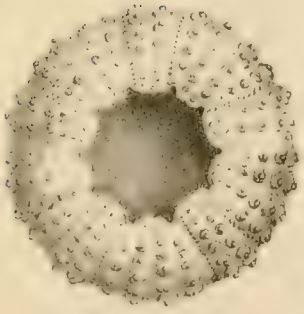


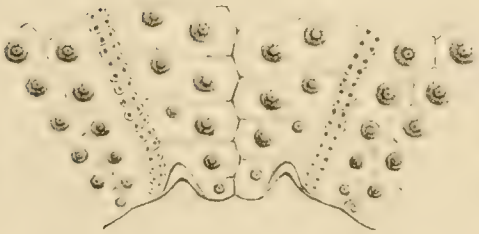


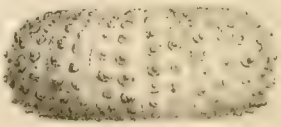












C.R. Bone del et lith

W West imp

PLATE XV.

From the Lower Greensand.

Fig. 1 *a*. Pseudodiadema Fittonii, *Wright*, test natural size, cabinet of Dr. Wright, F.R.S.E. (P. 90.)

1 *b*. Upper surface magnified one half.

1 *c*. Under surface do. do.

1 *d*. Lateral view do. do.

1 *e*. Ambulacra, poriferous zones, and interambulacra, magnified four times.

1 *f*. Portion of an ambulacra, magnified four times.

1 *g*. One tubercle and pores, magnified six times.

From the Upper Greensand.

Fig. 2 *a*. Pseudodiadema Benettiæ, *Forbes*, magnified one half, British Museum, and cabinet of Dr. Wright, F.R.S.E. (P. 101.)

2 *b*. Upper surface of the same test do. do.

2 *c*. Lateral view of do. do. do.

2 *d*. Ambulacra, zones, and interambulacra, magnified four times.

2 *e*. Ambulacra seen in profile do. do.

2 *f*. Inter-ambulacral plate and tubercle, magnified six times.

1d

1b

1c

1e

1a

1f

1g

2d

2c

2c

2a

2f

2b

C.R. Bone del. et lith.

W. West imp

PLATE XVI.

From the Gault.

Fig. 1 *a*. Pseudodiadema Wiltshirii, *Wright*, natural size, belonging to the Rev. T. Wiltshire, F.G.S. (P. 94.)

1 *b*. Lateral view of the same test, magnified one half.

1 *c*. Ambulacra, zones, and interambulacra, magnified four times.

1 *d*, *e*. Primary tubercle, magnified six times.

1 *f*. Portion of a spine, magnified six times.

Fig. 2. Spine magnified.

Fig. 3. Do., natural size.

From the Grey Chalk.

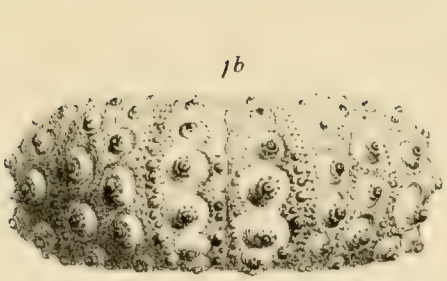
Fig. 4 *a*. Pseudodiadema ornatum, *Goldfuss*, sp., upper surface, magnified one half, belonging to the British Museum. (P. 103.)

4 *b*. Under surface of the same, magnified one half.

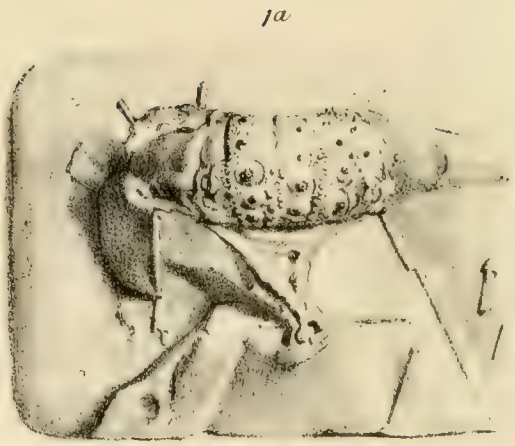
4 *c*. Lateral view of the same, do. do.

4 *d*. Ambulacral area, interambulacral area, and pores, magnified four times.

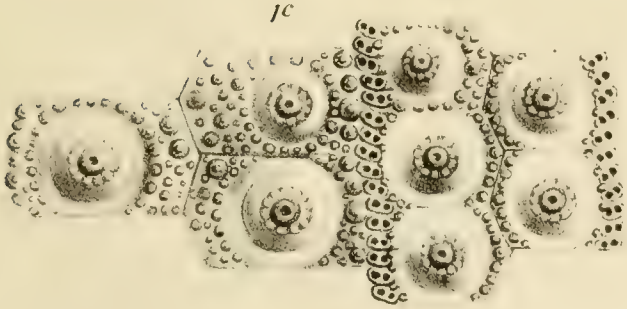
4 *e*. Miliary zone and upper portion of an ambulacrum, do. do.


1b

2


1a

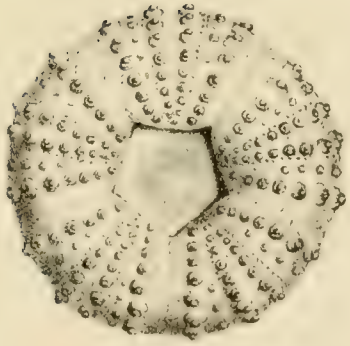
1f


1c

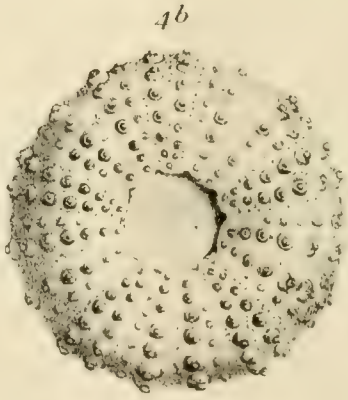
1e

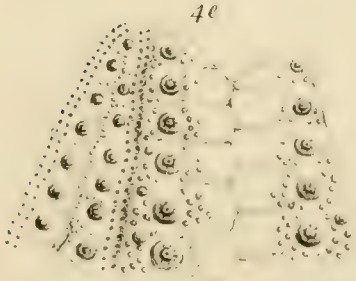
1d

3


4a

4c


4b


4e

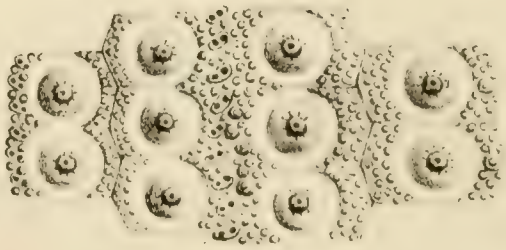

4d

PLATE XVII.

From the Chalk Marl.

PSEUDODIADEMA VARIOLARE, *Brongniart*, sp.

Fig. 1 *a*. Test, the natural size, with spines. British Museum. (P. 107.)

1 *b*. Spine, greatly magnified.

Fig. 2. Test, magnified one half. In the cabinet of Dr. Wright, F.R.S.E.

Fig. 3 *a*. Lateral view, magnified one half. Do.

3 *b*. Base view, do. Do.

3 *c*. Upper surface, do. Do.

Fig. 4. Ambulacral area and some inter-ambulacral plates, magnified six times. Dr. Wright's cabinet.

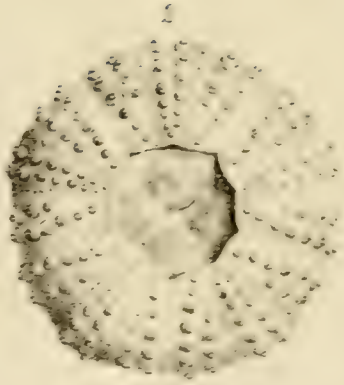
Fig. 5 *a*. Upper portion of the ambulacral and poriferous zone, showing the hyponimal pores, magnified six times.

5 *b*. Inter-marginal portion of the ambulacral area, showing the triple oblique pairs of holes at the base of the area, magnified six times.

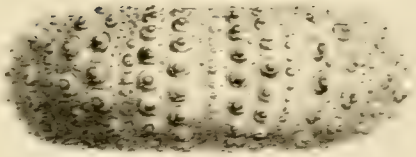
1a

5b

2



5c



3b

1b

3a

4

5a

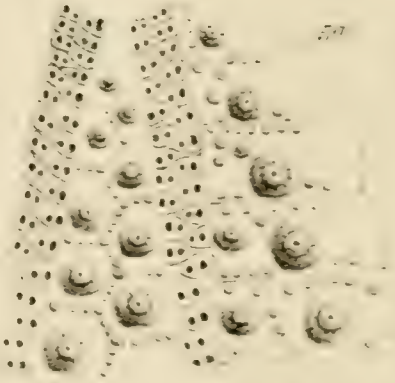


PLATE XVIII.

From the Grey Chalk.

Fig. 1 *a*. PSEUDODIADEMA VARIOLARE, *Brongniart*. Upper surface of a large test, in the cabinet of the Rev. T. Wiltshire, F.G.S. Restored, natural size. (P. 107.)

1 *b*. Under surface of the same, do. Do.

1 *c*. Ambulacral plate, magnified six diameters.

From the Chloritic Marl.

Fig. 2. PSEUDODIADEMA VARIOLARE, *Brongniart*. A very perfect specimen from Chard, in the cabinet of Dr. Wright, F.R.S.E. Magnified one half diameter.

Fig. 3 *a*. PSEUDODIADEMA RHODANI, *Agassiz*. Upper surface, magnified one half. In the cabinet of Dr. Wright, F.R.S.E. (P. 96.)

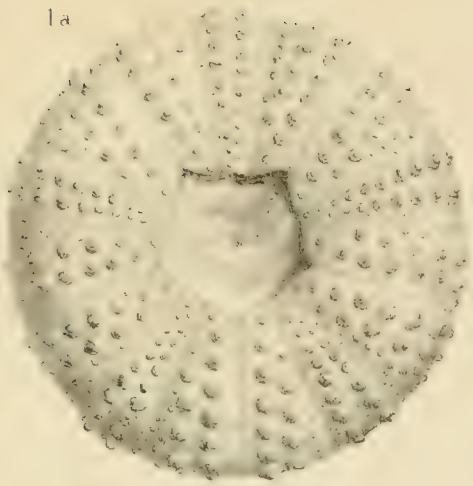
3 *b*. Under surface of the same. Do. Do.

3 *c*. Lateral view of do. Do. Do.

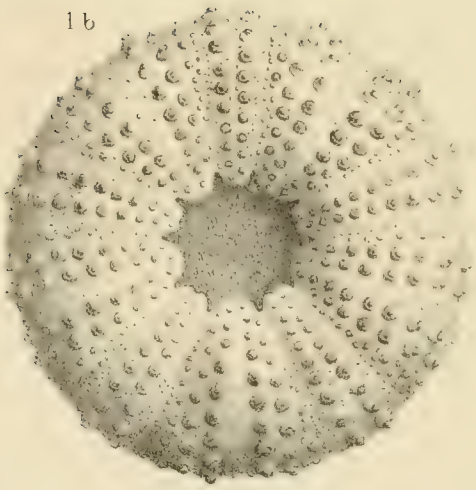
3 *d*. Ambulacra, inter-ambulacra, and pores, magnified four times.

3 *e*. Four inter-ambulacral plates, magnified four times.

1a

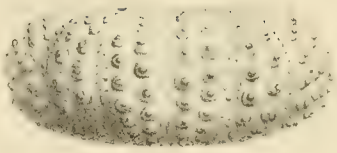


1b



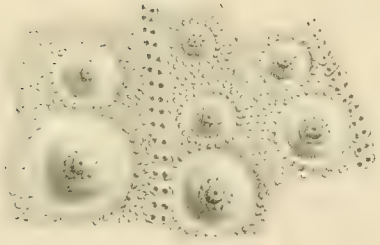
x6 1c

2.



3d

x4

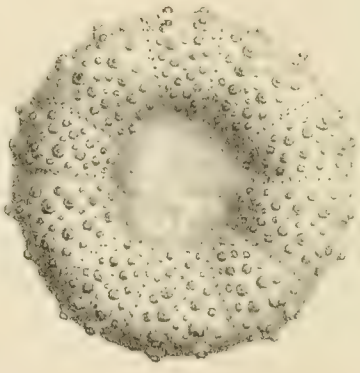


x4 3e

3a

3c

3b



R. Pone del et lith.

M & N Hanhart Imp.

PLATE XIX.

From the Grey Chalk.

Fig. 1 *a*. Pseudodiadema ornatum, *Goldfuss*. Test, natural size, in the cabinet of Dr. Wright, F.R.S.E. (P. 103.)

1 *b*. Same test restored and magnified half a diameter, showing the base.

1 *c*. Lateral view of do. do., do.

1 *d*. Portion of the ambulacra, inter-ambulacra, and zones, magnified four times.

1 *e*. Inter-ambulacra, plate, and tubercle, magnified six times.

From the Upper Greensand.

Fig. 2 *a*. Pseudodiadema Michelini, *Agassiz*. Upper surface, magnified one half. In the cabinet of Dr. Wright, F.R.S.E. (P. 99.)

2 *b*. Under surface of the same test, do. Do.

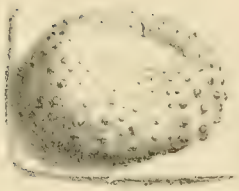
2 *c*. Lateral view of do., do. Do.

2 *d*. Portion of ambulacra, inter-ambulacra, and pores, magnified four times.

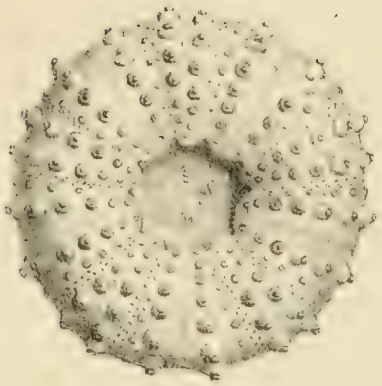
2 *e*. Do. magnified four times.

2 *f*. Base of the ambulacra, do.

1a

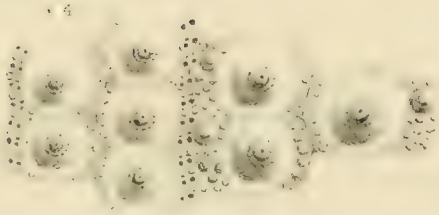


1b

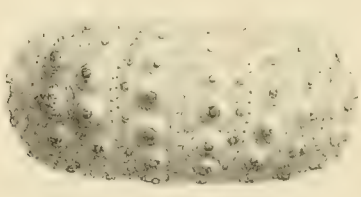


1c

1d

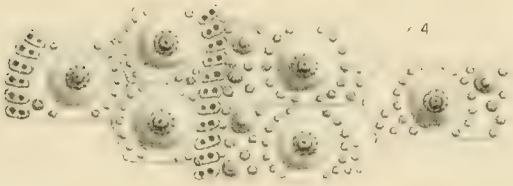


1e



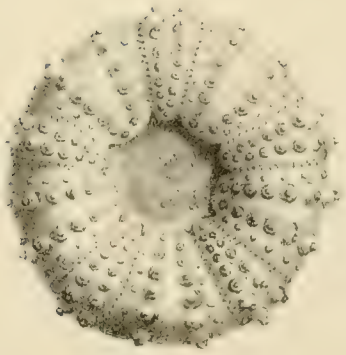
2f

2d

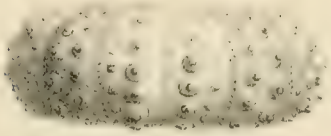


2e

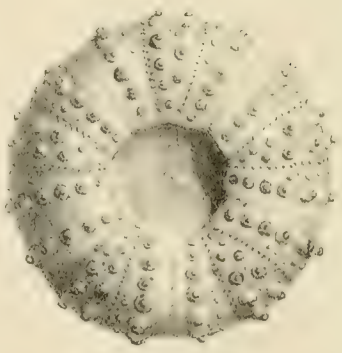
2b



2c



2a



C R Bone del et lith

M & N Hanhart, Imp

PLATE XX.

From the Lower Greensand.

Fig. 1 *a*. Pseudodiadema Malbosi, *Agassiz*. Upper surface of the test, natural size. From the Collection of the Rev. T. Wiltshire, F.G.S. (P. 91.)

1 *b*. Upper surface of the same specimen.

1 *c*. Lateral view of do.

1 *d*. Inter-ambulacral plates, ambulacral area, and poriferous zones, magnified four times.

1 *e*. Basal portion of an ambulacral area, magnified four times.

1 *f*. Portion of a primary spine, magnified five times.

From the Grey Chalk.

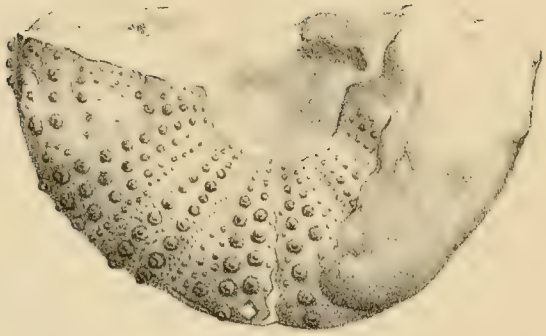
Fig. 2 *a*. Pseudodiadema Brongniarti, *Agassiz*. Fragment of a large test, upper surface, natural size, in the cabinet of Rev. T. Wiltshire, F.G.S. (P. 111.)

2 *b*. Under surface of the same, do.

2 *c*. Base of the ambulacral area, magnified four times.

2a

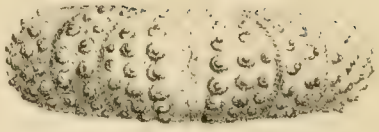
2b



2c

1g

1c



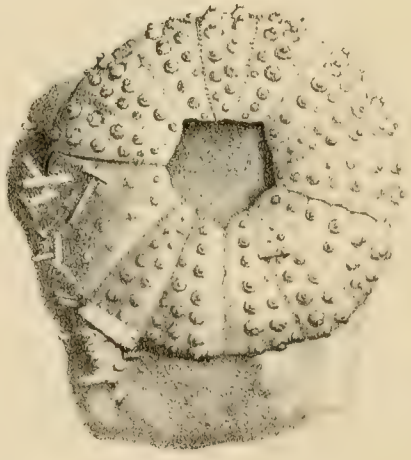
1f

1d

1b

1e

1a



C.R. Bone del. et lith

W.West imp

PLATE XXI.

From the Chloritic Marl.

Fig. 1 *a*. PSEUDODIADEMA ORNATUM, *Goldfuss*. Upper surface, magnified one half, in the cabinet of Dr. Wright, F.R.S.E. (P. 103.)

1 *b*. Lateral view of the same test, magnified one half.

1 *c*. Portion of the ambulacra, inter-ambulacra and pores, magnified four times.

1 *d*. Do. do. and spine, magnified four times.

From the Grey Chalk.

Fig. 2 *a*. Another specimen, with spines, in the cabinet of the Rev. T. Wiltshire, F.G.S.

2 *b*. Portion of the ambulacra, inter-ambulacra and zones, magnified four times.

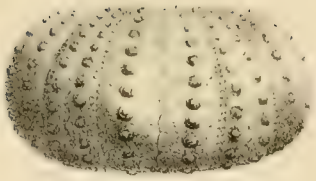
Fig. 3 *a*. PSEUDODIADEMA NORMANIÆ, *Cotteau*. Upper surface of the test, natural size, in the cabinet of the Rev. T. Wiltshire, F.G.S. (P. 105.)

3 *b*. Lateral view of the same, natural size.

3 *c*. Ambulacral and inter-ambulacral plates, magnified four times.

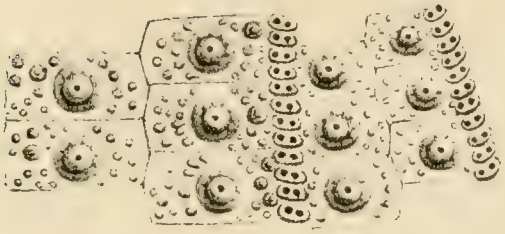
3 *d*. Ambulacral area, magnified three times.

1b

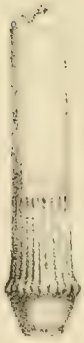


1a

1c

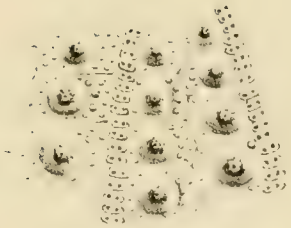


1c



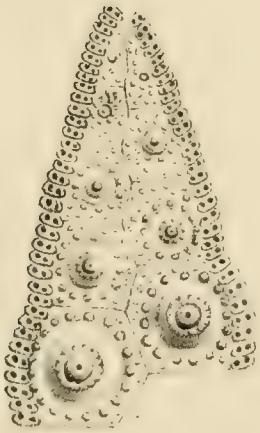
2a

2b



3c

3d



3a

3b

PLATE XXI A.

From the Grey Chalk.

Fig. 1 *a*. PSEUDODIADEMA ORNATUM, *Goldfuss*, from the cabinet of the Rev. T. Wiltshire, F.G.S. Upper surface, natural size. (P. 103.)

1 *b*. Under surface, natural size.

Fig. 2 *a*. PSEUDODIADEMA BRONGNIARTI, *Agassiz*. British Museum, natural size. (P. 111.)

2 *b*. „ „ Upper surface, magnified one half diameter

2 *c*. „ „ Under surface, do. do.

2 *d*. „ „ Lateral view, do. do.

2 *e*. „ „ Ambulacral area, poriferous zones, and one half of an inter-ambulacral area, magnified six times.

2 *f*. „ „ Primary tubercle, magnified.

Fig. 3. „ „ Spines, natural size.

Fig. 4. „ „ Portion, magnified six times.

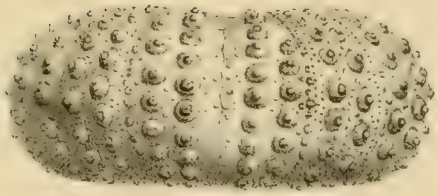
1a

4

3

1b

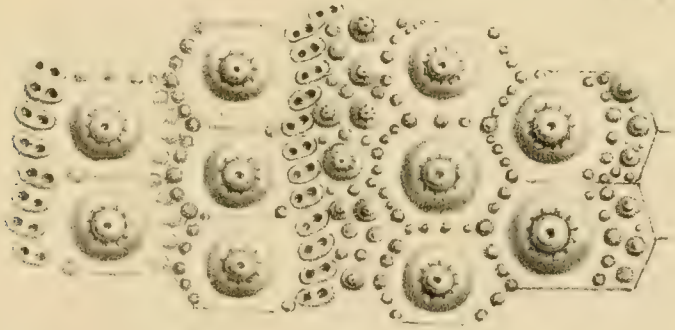
2d



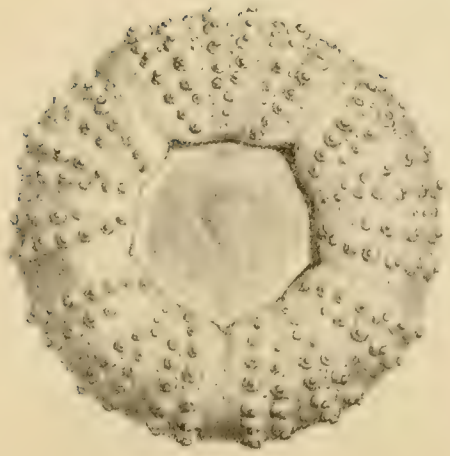
2f

2a

2e



2b



2c

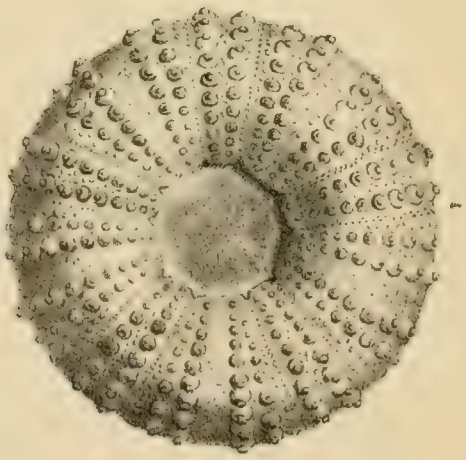


PLATE XXI B.

From the Red Chalk.

Fig. 1 *a*. PSEUDODIADEMA BRONGNIARTI, *Agassiz*. Cabinet of the Rev. T. Wiltshire, F.G.S. (P. 111.)

1 *b*. Lateral view of the same. Both natural size.

Fig. 2. Another specimen, belonging to C. B. Rose, Esq., F.G.S.

From the Grey Chalk.

Fig. 3 *a*. PSEUDODIADEMA BRONGNIARTI, *Agassiz*. Cabinet of the Rev. T. Wiltshire, F.G.S.

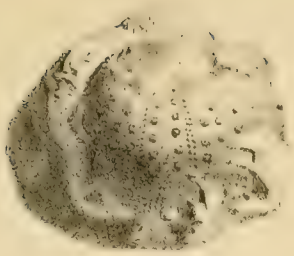
3 *b*. The test restored from this fine large specimen. Upper surface.

3 *c*. Do. do. do. Under surface.

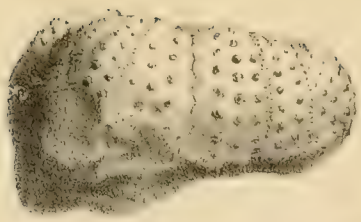
3 *d*. Do. do. do. Lateral view.

3 *e*. Portion of the ambulacra, inter-ambulacra and pores, magnified four times.

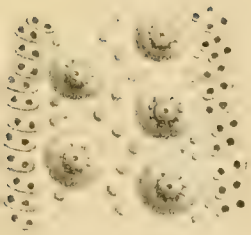
2



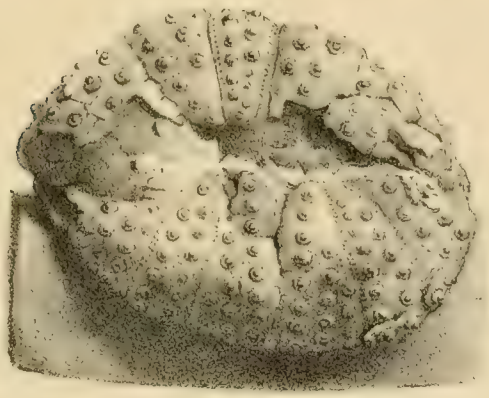
1b



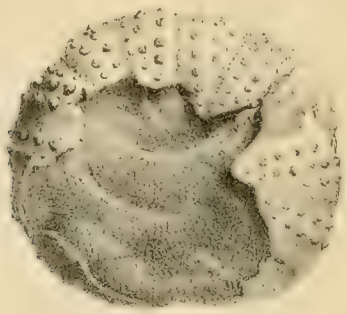
1c



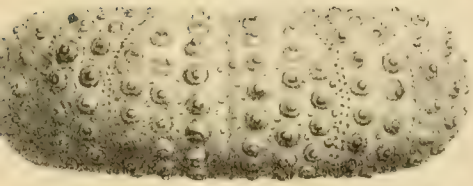
3a



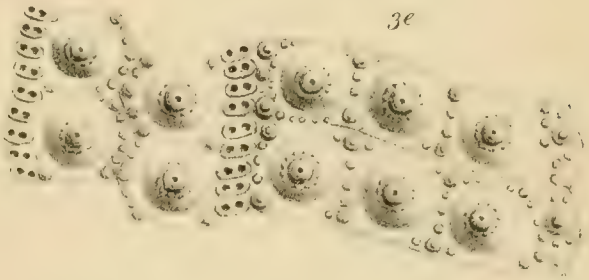
1a



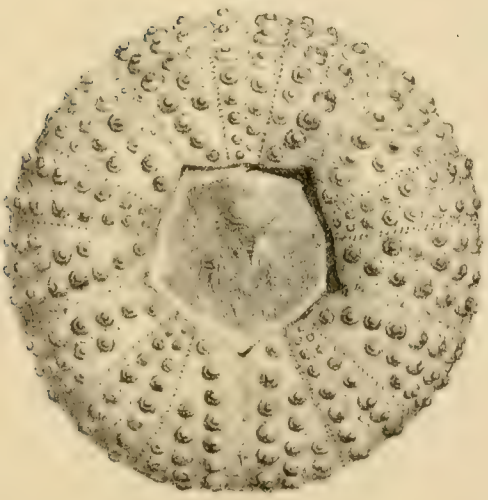
3d



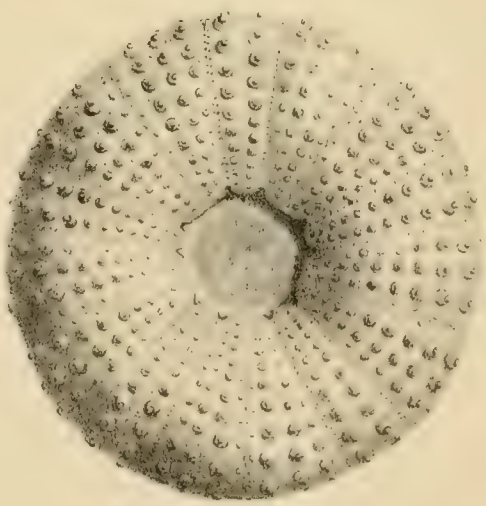
3e



3b



3c



C R.Bone del. et lith

W West imp

PLATE XXII.

Echinocyphus from the Grey Chalk.

Fig. 1 *a*. Echinocyphus difficilis, *Agassiz*. Test, natural size. British Museum. (P. 116.)

1 *b*. Ambulacral and inter-ambulacral plates, magnified four diameters, do. Do.

Fig. 2 *a*. Echinocyphus difficilis. Upper surface, magnified three diameters. The Rev. T. Wiltshire, F.G.S.

2 *b*. ,, ,, Under surface, do. do. Do.

2 *c*. ,, ,, Lateral view, do. do. Do.

2 *d*. ,, ,, Ambulacral and inter-ambulacral plates, magnified six times.

Fig. 3 *a*. Echinocyphus mespilia, *Woodward*, sp. Test, natural size. (P. 119.) British Museum.

3 *b*. ,, ,, Upper surface, magnified three diameters.

3 *c*. ,, ,, Under surface, do. do.

3 *d*. ,, ,, Lateral view, do. do.

3 *e*. ,, ,, Ambulacral and inter-ambulacral plates, magnified eight diameters.

Fig. 4. Echinocyphus difficilis. Apical disc, magnified four times.

Fig. 5 *a*. Cyphosoma Königi, *Mantell*. Young test, natural size. British Museum. (P. 131.)

5 *b*. ,, ,, Under surface, do. Do.

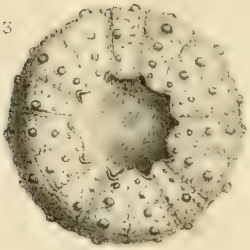
5 *c*. ,, ,, Lateral view, do. Do.

5 *d*. ,, ,, Upper third of ambulacrum, magnified four times.

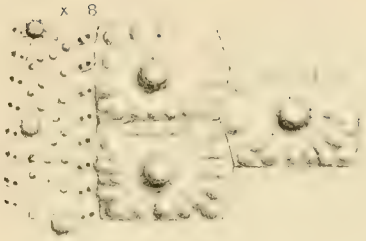
3b x 3

3d x 3

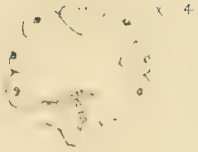
3c x 3



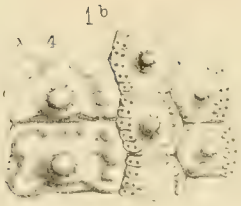
3 x 8



4 x 4

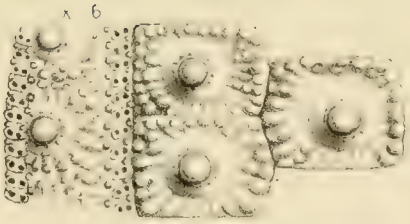


1b x 4



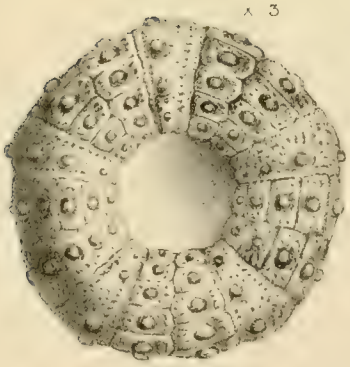
3a

2d x 6



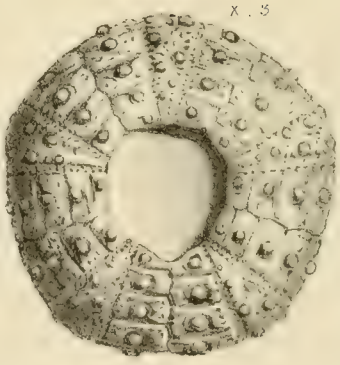
1d

2b x 3



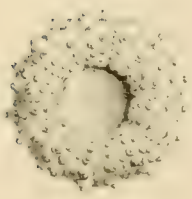
2c x 3

2a x 3

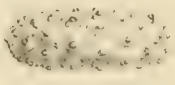


5d x 4

5b



5c



5a

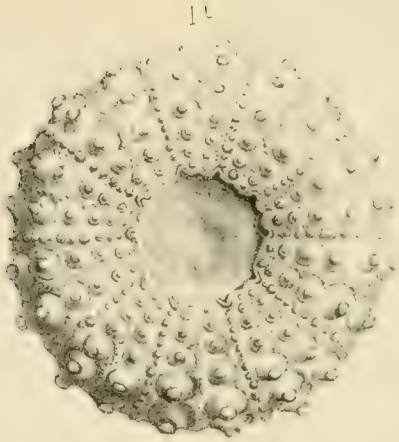
PLATE XXIII.

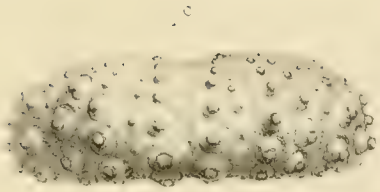
From the Upper White Chalk.

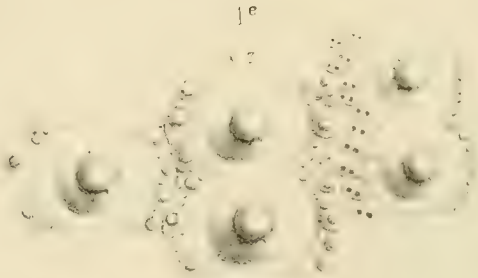
Fig. 1 *a*. Cyphosoma Königi, *Mantell*. Upper surface, natural size. (P. 131.)
1 *b*. ,, ,, Under surface, natural size. British Museum.
1 *c*. ,, ,, Lateral view, do.
1 *d*. ,, ,, Upper part of ambulacral area, magnified three times.
1 *e*. ,, ,, Portion of the areas and pores, magnified three times.
1 *f*. ,, ,, Boss and mammillon, highly magnified.
1 *g*. ,, ,, Inferior portion of an ambulacrum, magnified three times.

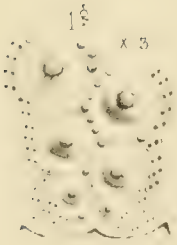
Fig. 2 *a*. Cyphosoma granulosum, *Goldfuss*. Upper surface, natural size. (P. 129.)
2 *b*. ,, ,, Under surface, natural size. British Museum.
2 *c*. ,, ,, Lateral view, showing the depression of the upper surface.
2 *d*. ,, ,, Portion of the areas and pores, magnified four times.

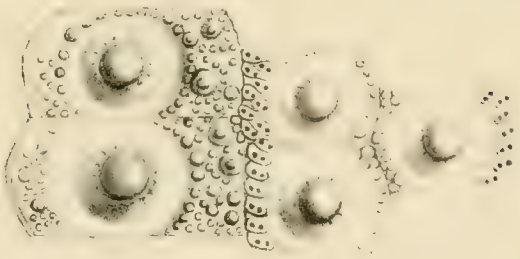
Fig. 3. Cyphosoma Königi, *Mantell*. Elevated variety. British Museum.

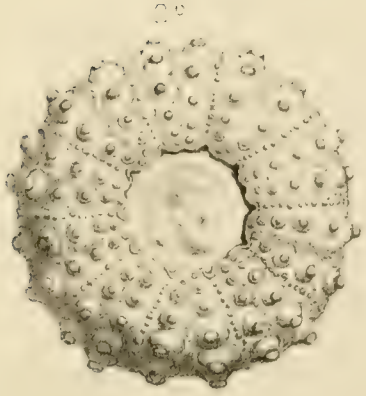












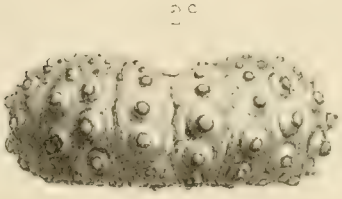


PLATE XXIV.

From the Upper White Chalk.

Fig. 1 *a*. CYPHOSOMA KÖNIGI, *Mantell*. A fine specimen, with the spines *in sitú*, natural size. British Museum. (P. 131.)

1 *b*. ,, ,, Ramiform spine, natural size.

1 *c*. ,, ,, do., do., magnified three times.

1 *d*. ,, ,, Bent spine, magnified twice.

Fig. 2. ,, ,, Test, with spines. Rev. T. Wiltshire, F.G.S. Natural size.

3 *a*. ,, ,, Bent spine

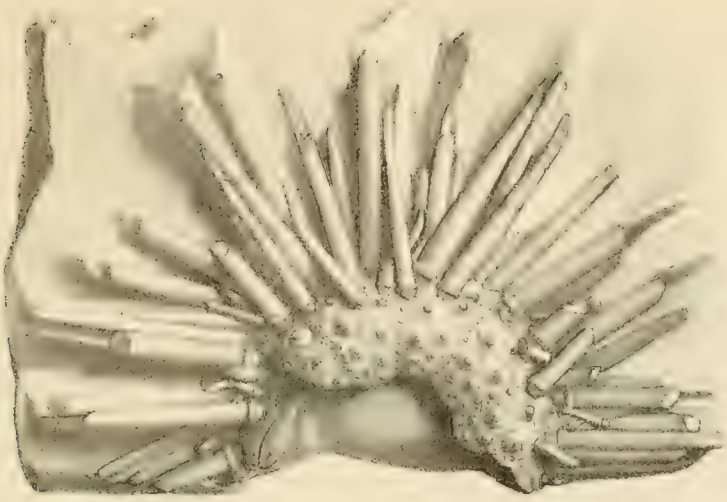
3 *b*. ,, ,, do., magnified six times } British Museum.

4. ,, ,, Spatulate, do.

6. ,, ,, Inter-ambulacral plate, magnified six times.

7. ,, ,, Elevated variety. British Museum.

1.a.



4.b

× 3

3

1.c.

× 3

1.b.

7.

2.

2.b

× 3

4.a

3.a

C.R.Bone. del et lith.

M&N.Hanhart, Imp.

PLATE XXV.

Cyphosomas from the Upper White Chalk.

Fig. 1 *a*. CYPHOSOMA MAGNIFICUM, *Agassiz*. Natural size. Rev. T. Wiltshire. (P. 137.)

1 *b*. ,, ,, Upper surface, magnified twice. Do.

1 *c*. ,, ,, Under surface, do. Do.

1 *d*. ,, ,, Lateral view, do. Do.

Fig. 2 *a*. ,, ,, Upper part of areas, magnified four diameters.

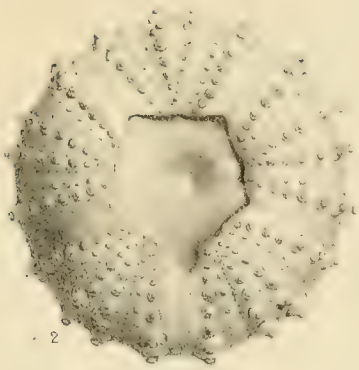
2 *b*. ,, ,, Base of ambulacrum, do. do.

2 *c*. ,, ,, Tubercle, magnified six diameters.

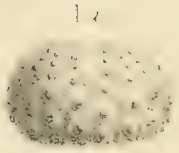
Fig. 3 *a*. CYPHOSOMA KÖNIGI, *Mantell*. Mould in flint. Upper surface. (P. 131.)

3 *b*. ,, ,, Do. Under do.

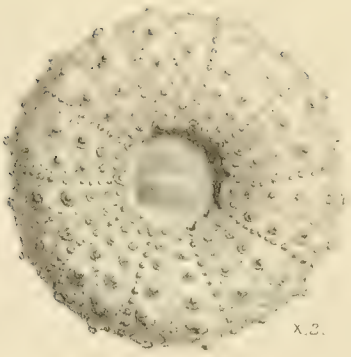
1 b



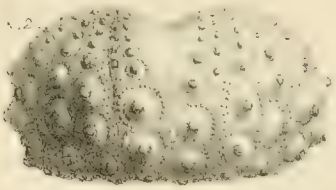
1 a



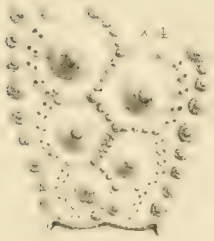
1 c



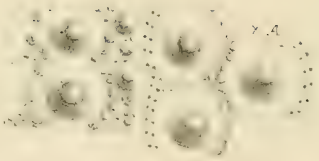
1 d



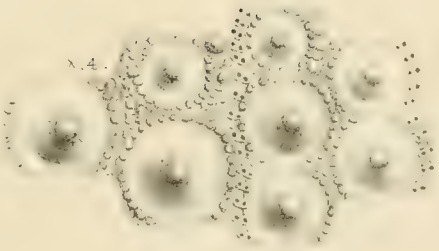
2 b



2 a

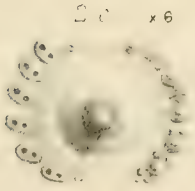


1 e

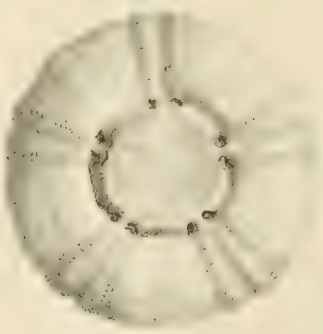


3 a

2 c



3 b



G R Bone . del et Lith.

M & N Hanhart, Imp.t

PLATE XXVI.

Cyphosomas from the Upper White Chalk.

Fig. 1 *a*, *b*, *c*. CYPHOSOMA KÖNIGI. Spoon-shaped spines, magnified. The Rev. T. Wiltshire, F.G.S.

2. „ „ Club-shaped spine, do. Do.

3 *a*, *b*. „ „ Awl-shaped spine, magnified six times. Do.

4, 5, 6. „ „ Conical and spoon-shaped, do. Do.

Fig. 7 *a*. CYPHOSOMA COROLLARE, *Klein*. Test, natural size. British Museum. (P. 134.)

7 *b*. „ „ Upper third of an ambulacrum, magnified six times.

7 *c*. „ „ Inter-ambulacral plates, do. do.

8 *a*. „ „ Upper surface of another test, magnified twice, do.

8 *b*. „ „ Lateral view of do., do., do.

9. „ „ Under surface of do., do., do.

10. „ „ Ambulacral area, magnified six times. The Rev. T. Wiltshire, F.G.S.

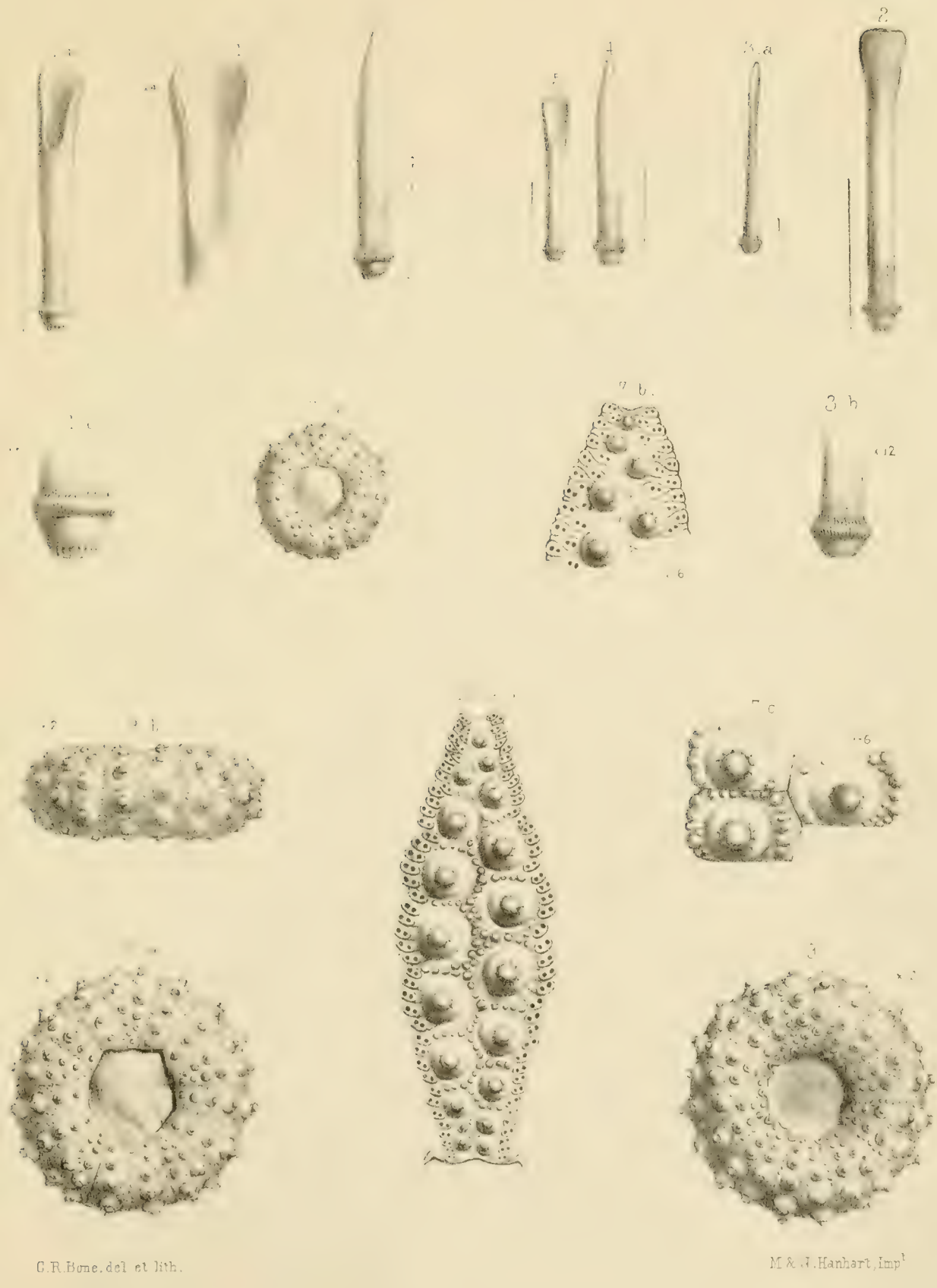


PLATE XXVII.

From the Upper White Chalk.

Fig. 1 *a*. CYPHOSOMA WETHERELLI, *Forbes*. Test, natural size. Museum of the Royal School of Mines. (P. 139.)

1 *b*. ,, ,, The upper surface of do., magnified twice.

1 *c*. ,, ,, The under surface of do., do.

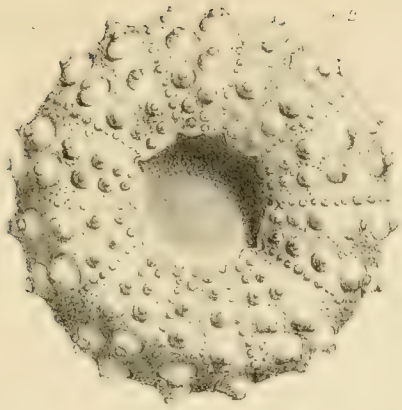
1 *d*. ,, ,, The lateral view of do., do.

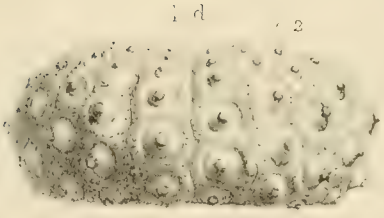
1 *e*. ,, ,, Areal plates and zones, magnified six times.

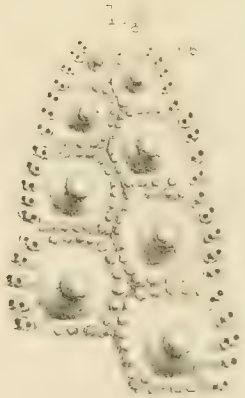
1 *f*. ,, ,, Lateral view of a single tubercle, magnified.

1 *g*. ,, ,, Upper portion of an ambulacrum, magnified six times.

1 *h*. ,, ,, Inferior portion of do., do.







C R Bone, del et lith.

Imp. Hanhart, Imp.t

PLATE XXVIII.

From the Upper White Chalk.

Fig. 1 *a*. CYPHOSOMA SPATULIFERUM, *Forbes*. Test, natural size. British Museum. (P. 141.)

1 *b*. ,, ,, Upper surface of do., magnified twice.

1 *c*. ,, ,, Under surface of do., do. do.

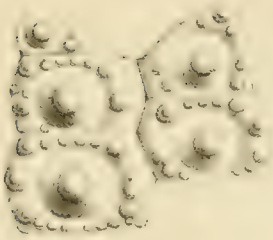
1 *d*. ,, ,, Lateral view of do., do. do.

1 *e*. ,, ,, Inter-ambulacral plates, do. six times.

1 *f*. ,, ,, Ambulacrum entire, do. do.

1 *g*. ,, ,, Inter-ambulacral plates, do. do.

1 *h*. ,, ,, Lower portion of an ambulacrum, magnified six times.



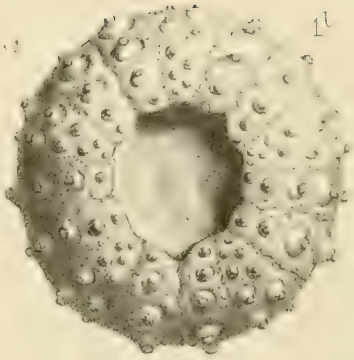


PLATE XXIX.

From the Upper and Lower Chalk.

Fig. 1 *a*. CYPHOSOMA SPATULIFERUM, var. The Rev. T. Wiltshire, F.G.S. (P. 141.)

1 *b*. „ „ Upper surface of do., magnified twice.

1 *c*. „ „ Lateral view of do., do. do.

1 *d*. „ „ Areal plates and zones, do. six times.

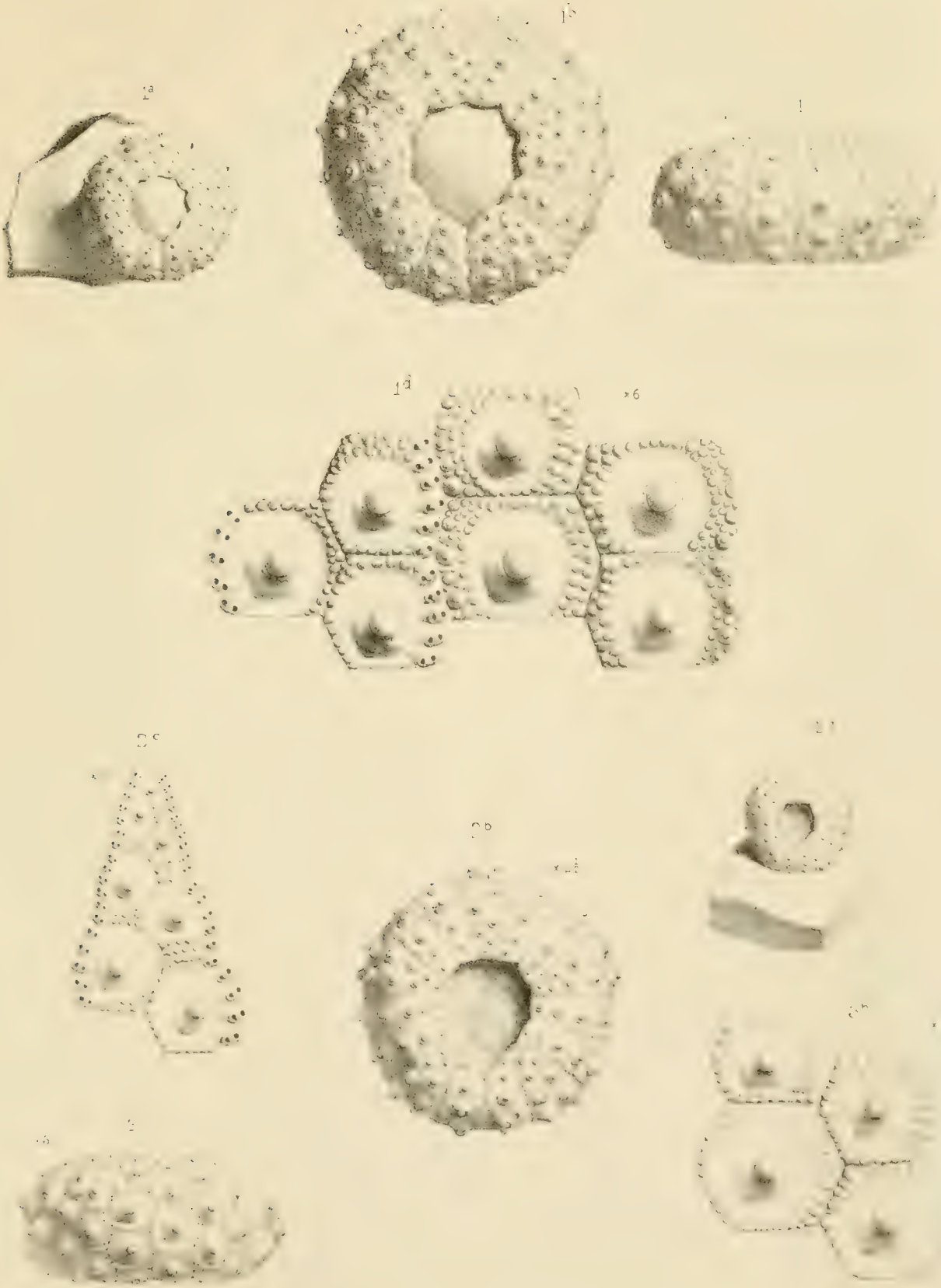
2 *a*. CYPHOSOMA SIMPLEX, *Forbes*. Royal School of Mines. (P. 143.)

2 *b*. „ „ Upper surface of test, magnified two and a half times.

2 *c*. „ , Upper portion of ambulacra, do. six times.

3 *a*. „ „ Another test, magnified three times.

3 *b*. „ „ Radiated areolæ, magnified eight times, Museum of the Royal School of Mines.



M & N Herbert imp.

PLATE XXIX A.

From the Chloritic Marl.

Fig. 1 *a*. PEDINOPSIS WIESTI, *Wright*. Test, natural size, upper. From the Collection of W. Wiest. (P. 114.)

1 *b*. ,, ,, Under surface of do., natural size.

1 *c*. ,, ,, Lateral view of do., do.

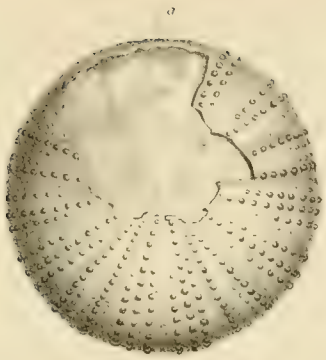
1 *d*. ,, ,, Upper third of an ambulacrum, magnified six times.

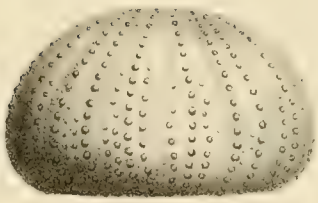
1 *e*. ,, ,, Inter-ambulacrum plates, do., do.

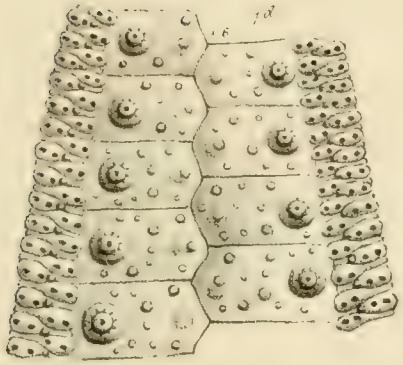
1 *f*. ,, ,, Do. do., do., do.

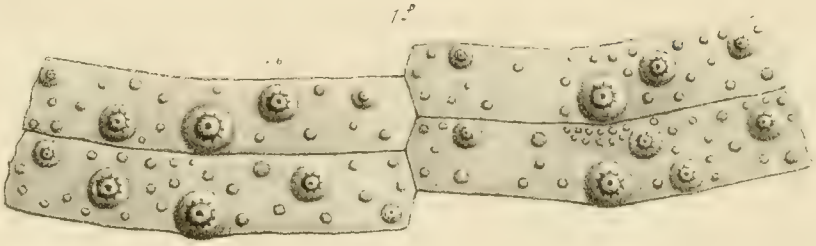
1 *g*. ,, ,, Areal plates and zones, do., do.

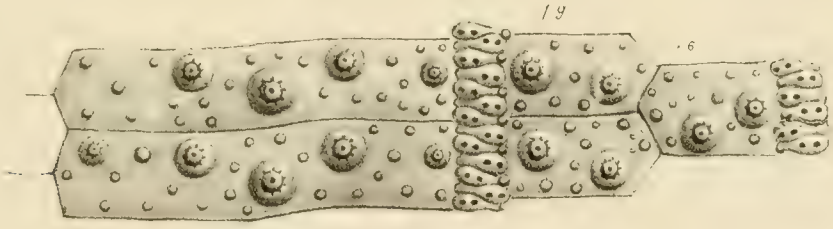
2. PEDINOPSIS MERIDANENSIS, *Cotteau*. Copied from Pl. 1125, fig. 2, of the 'Paléontologie Française,' for comparison with *P. Wiesti*.

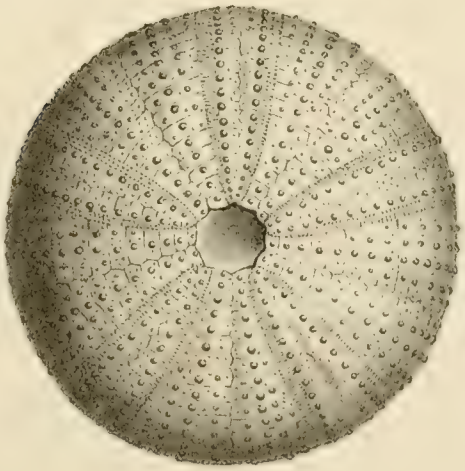


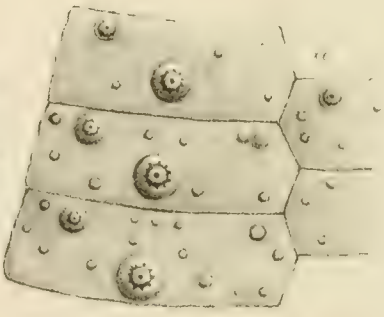












C.R.Bone del. et lith

M&N Hanhart imp

PLATE XXIX B.

From the Upper and Lower Chalk.

Fig. 1 *a*. GLYPHOCYPHUS RADIATUS, *Hœninghaus*, sp. Test, upper surface, magnified twice. (P. 121.)

1 *b*. ,, ,, Lateral view, magnified twice.

1 *c*. ,, ,, Areal plates and zones, do. ten times.

Fig. 2 *a*. ,, ,, Under surface, do. twice.

2 *b*. ,, ,, Apical disc (from M. Cotteau's figure), magnified.

2 *c*. ,, ,, Areal plates and zones (do. do.) do.

2 *d*. ,, ,, Inter-ambulacrum (do. do.) do.

2 *e*. ,, ,, Ambulacrum (do. do.) do.

Fig. 3 *a*. ECHINOTHURIA FLORIS, *Woodward*. Portion of test, natural size, in the British Museum. (P. 125).

3 *b*. ,, ,, Poriferous zones, magnified four times, do.

Fig. 4 *a*. ,, ,, Do. do., do. do.

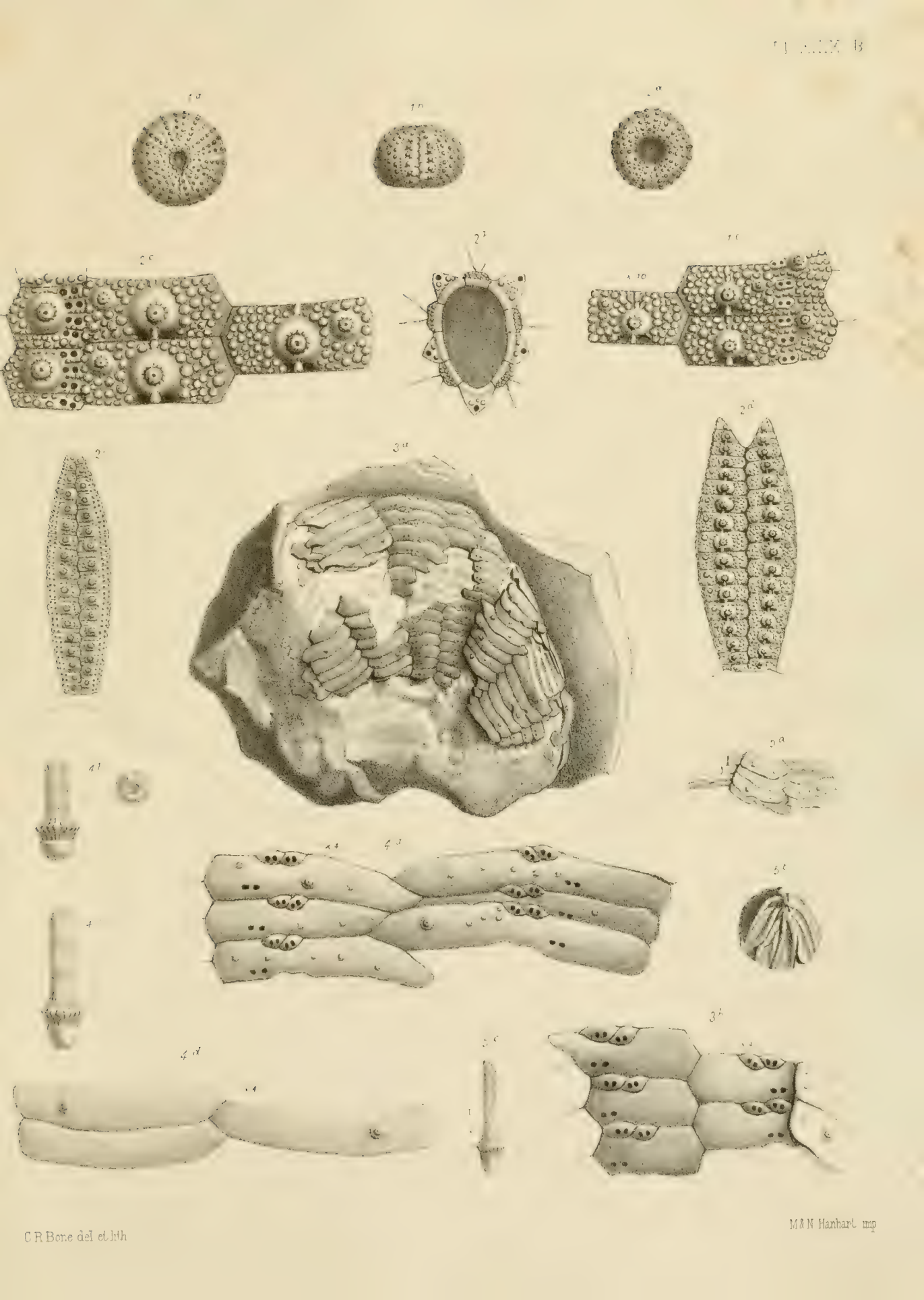
4 *b*. ,, ,, Portion of spine, do. six times.

4 *c*. ,, ,, Do. do., do. do.

4 *d*. ,, ,, Areal plates, do. four times.

5 *a*. ,, ,, Ovarial plates, natural size.

5 *b* ,, ,, Jaws, forming "the Lantern of Aristotle," natural size.



C.R.Bone del. et lith.

M & N Hanhart imp.

PLATE XXX.

From the Neocomian or Lower Greensand.

Fig. 1 *a*. PELTASTES WRIGHTII, *Desor*. Test, natural size. British Museum. (P. 150.)

b. „ „ Upper surface, showing disc magnified twice.

c. „ „ Under surface, mouth opening and peristome, magnified twice.

d. „ „ Lateral view of the same, magnified twice.

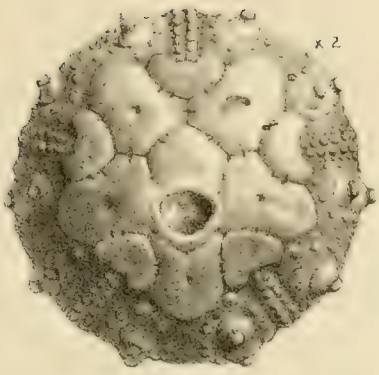
e. „ „ Upper portion of an inter-ambulacral and ambulacral area, magnified four times.

f. „ „ Inter-ambulacral tubercle, magnified four times.

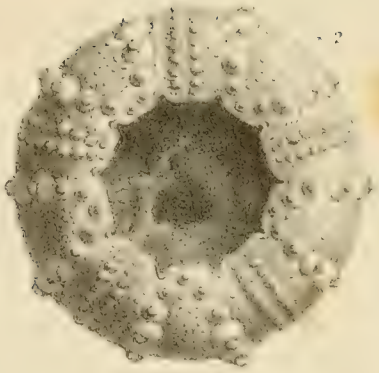
Fig. 2. „ „ Abnormal disc, suranal absent, do. twice.

1a

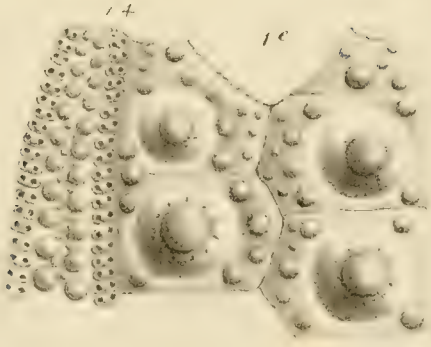
1b



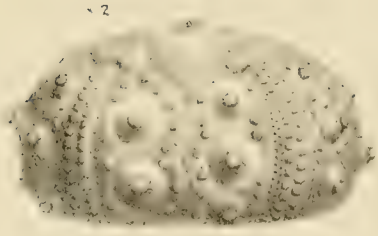
1c



1e 1e



1d



1f

2

PLATE XXXI.

From the Neocomian or Lower Greensand.

Fig. 1 *a*. PELTASTES STELLULATUS, *Agassiz*. Test, natural size. British Museum. (P. 152.)

1 *b*. ,, ,, Lateral view of do., magnified two diameters.

Fig. 2. ,, ,, Under surface, showing mouth opening and peristome, magnified two diameters.

Fig. 3 *a*. ,, ,, Upper surface, showing apical disc, magnified two diameters.

3 *b*. ,, ,, Upper portion of ambulacra and inter-ambulacra, magnified six diameters.

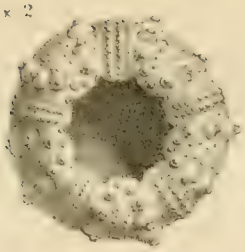
Fig. 4 *a*. PELTASTES LARDYI, *Desor*. Test, natural size. British Museum. (P. 154.)

4 *b*. ,, ,, Upper surface, showing apical disc magnified two diameters.

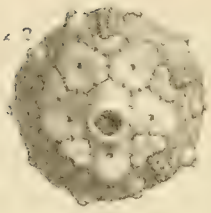
4 *c*. ,, ,, Lateral view of apical disc, magnified two diameters.

4 *d*. ,, ,, Upper portion of ambulacra, and inter-ambulacra, magnified four times.

2

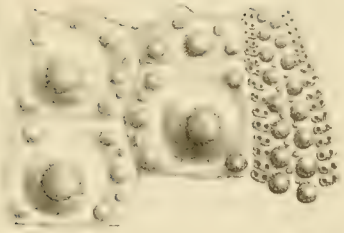


3 a

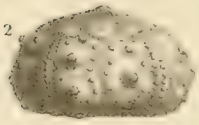


1 a

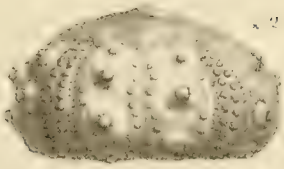
3 b



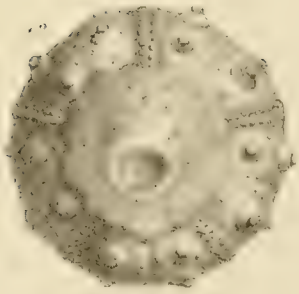
1 b



4 c



4 b



1 a

4 d

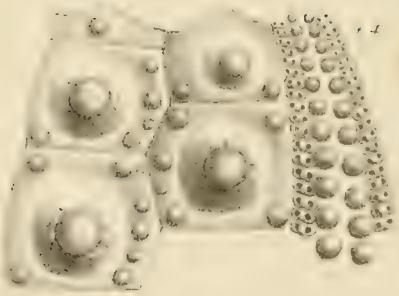


PLATE XXXII.

From the Upper Greensand.

Fig. 1 *a*. PELTASTES CLATHRATUS, *Agassiz*. Test, natural size. British Museum. (P. 156.)

1 *b*. ,, ,, Upper surface, showing the disc *in sitû*, magnified two diameters.

1 *c*. ,, ,, Under surface, showing mouth opening and peristome, magnified two diameters.

1 *d*. ,, ,, Ambulacra and inter-ambulacra, with poriferous zones, magnified six diameters.

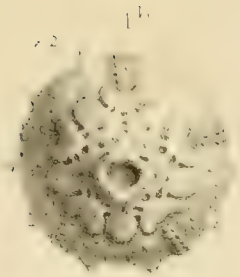
1 *e*. ,, ,, Single plate and portion of ambulacra with poriferous zones, magnified eight diameters.

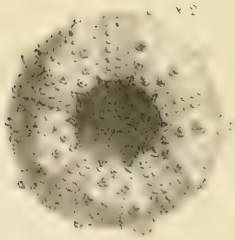
1 *f*. ,, ,, Mouth opening, magnified four diameters.

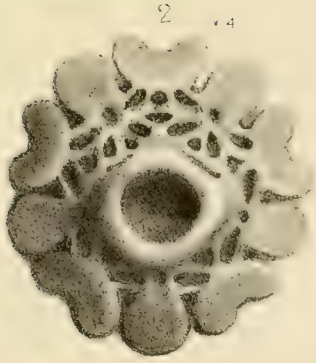
Fig. 2. ,, ,, Apical disc detached, magnified four diameters.

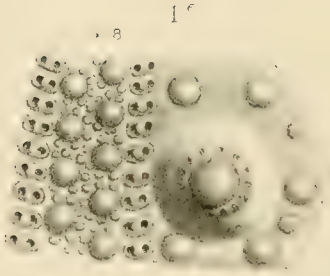
Fig. 3. ,, ,, Lateral view of another test, magnified two diameters.

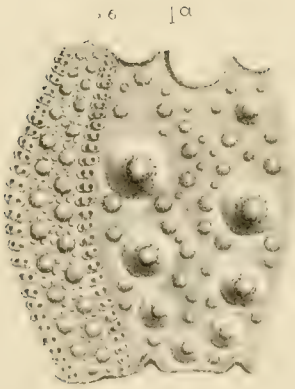
Fig. 4. ,, ,, Apical disc detached, magnified two diameters.











C R Bone del et lith.

M & N Hanhart imp

PLATE XXXIII.

From the Upper Greensand.

Fig. 1 *a*. SALENIA PETALIFERA, *Desmarest*. Test, natural size. British Museum.

1 *b*. ,, ,, Upper surface, showing disc *in sitú*, magnified two diameters.

1 *c*. ,, ,, Lateral view of the same test, magnified two diameters.

1 *d*. ,, ,, Ambulacra, inter-ambulacra, and poriferous zones, magnified four diameters.

1 *e*. ,, ,, Apical disc detached, magnified four diameters.

1 *f*. ,, ,, Single primary tubercle profile, magnified four diameters.

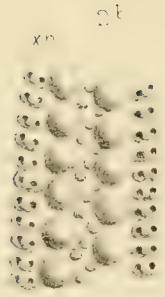
Fig. 2 *a*. ,, ,, Under surface, showing mouth opening and peristome, magnified two diameters.

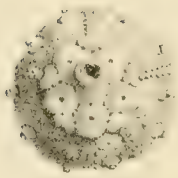
2 *b*. ,, ,, Ambulacra and poriferous zones, magnified six diameters.

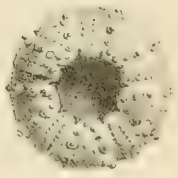
Fig. 3. ,, ,, Inferior portion of inter-ambulacra, magnified six diameters.

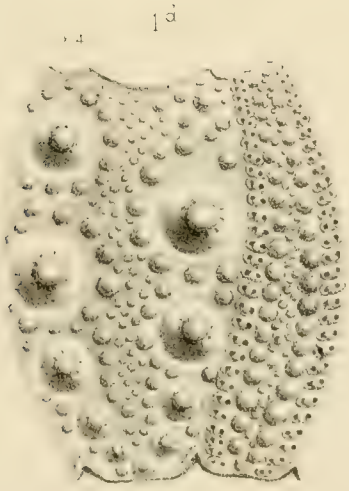
Fig. 4 *a*. ,, ,, Upper surface of another fine test, Mr. Cunnington, F.G.S.

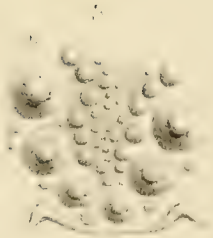
4 *b*. ,, ,, Under surface, do., do.











C.R.Bone del & lith.

M & N Hanhart imp

PLATE XXXIV.

From the Upper Greensand.

Fig. 1 *a*. PELTASTES UMBRELLA, *Agassiz*. Test, magnified two diameters. British Museum. (P. 158.)

1 *b*. .. .. Lateral view of the same, magnified two diameters.

1 *c*. .. .. Inter-ambulacra, ambulacra, and poriferous zones, magnified six diameters.

1 *d*. .. .. Apical disc detached, magnified four diameters.

Fig. 2. .. .. Under surface of another test, magnified two diameters. Mr. Cunnington, F.G.S.

Fig. 3. .. .. Apical disc of another test, magnified four diameters.

Fig. 4 *a*. SALENIA GIBBA, *Agassiz*. Test magnified, two diameters. British Museum.

4 *b* .. .. Under surface of do., do., do.

4 *c*. .. .. Lateral view of do., do., do.

4 *d*. .. .. Apical disc detached, four diameters, do.

4 *e*. .. .. Ambulacra, inter-ambulacra, and poriferous zones, magnified six diameters.

C R Bone del et lith

M & N Hanhart imp

PLATE XXXV.

From the Upper Greensand.

Fig. 1 *a*. Salenia Loriolii, *Wright*, nov. sp. Upper surface, magnified three diameters. British Museum.

1 *b*. ,, ,, Under surface, magnified three diameters.

1 *c*. ,, ,, Lateral view, do. do.

1 *d*. ,, ,, Ambulacra, inter-ambulacra, magnified six diameters.

Fig. 2 *a*. Salenia Desori, *Wright*, nov. sp. Upper surface, magnified three diameters.

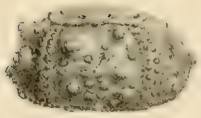
2 *b*. ,, ,, Under surface, do. do.

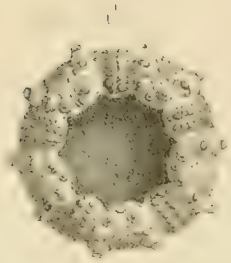
2 *c*. ,, ,, Lateral view, do. do.

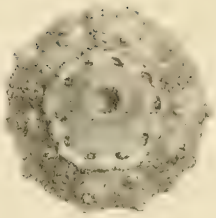
2 *d*. ,, ,, Apical disc, do. six do.

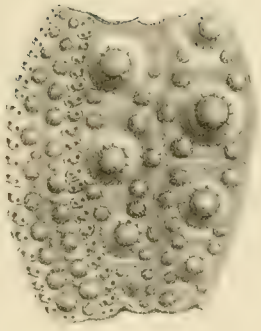
2 *e*. ,, ,, Ambulacra, inter-ambulacra, do.

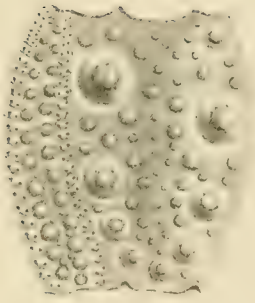
2 *f*. ,, ,, Single plate and ambulacra, eight do.

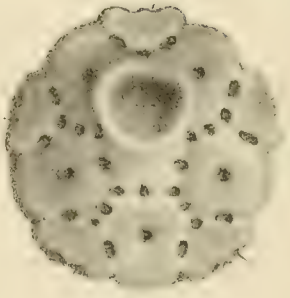


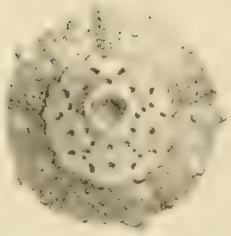


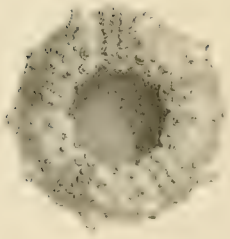


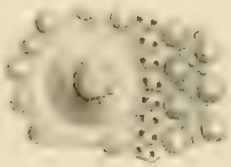












C.R.Bone del. et lith.

M.&N.Hanhart imp.

PLATE XXXVI.

From the Upper Greensand.

Fig. 1 *a*. GONIOPHORUS LUNULATUS, *Agassiz*. Test, natural size. Mr. Cunnington, F.G.S. (P. 163.)

1 *b*. „ „ Upper surface, showing disc magnified two diameters.

1 *c*. „ „ Under surface, showing mouth and peristome magnified two diameters.

1 *d*. „ „ Lateral view, inter-ambulacra, magnified two diameters.

Fig. 2 *a*. „ „ Inter-ambulacra, entire, magnified six diameters. Royal School of Mines.

2 *b*. „ „ Ambulacra, entire, magnified six diameters. Do. do.

2 *c*. „ „ Single plate of ambulacra, magnified six diameters.

From the Gault.

Fig. 3 *a*. GONIOPHORUS LUNULATUS, *Agassiz*. Test, with spines, *in sitú*, magnified two diameters. Rev. T. Wiltshire, F.G.S.

3 *b*. „ „ Ambulacra and inter-ambulacra, magnified six diameters.

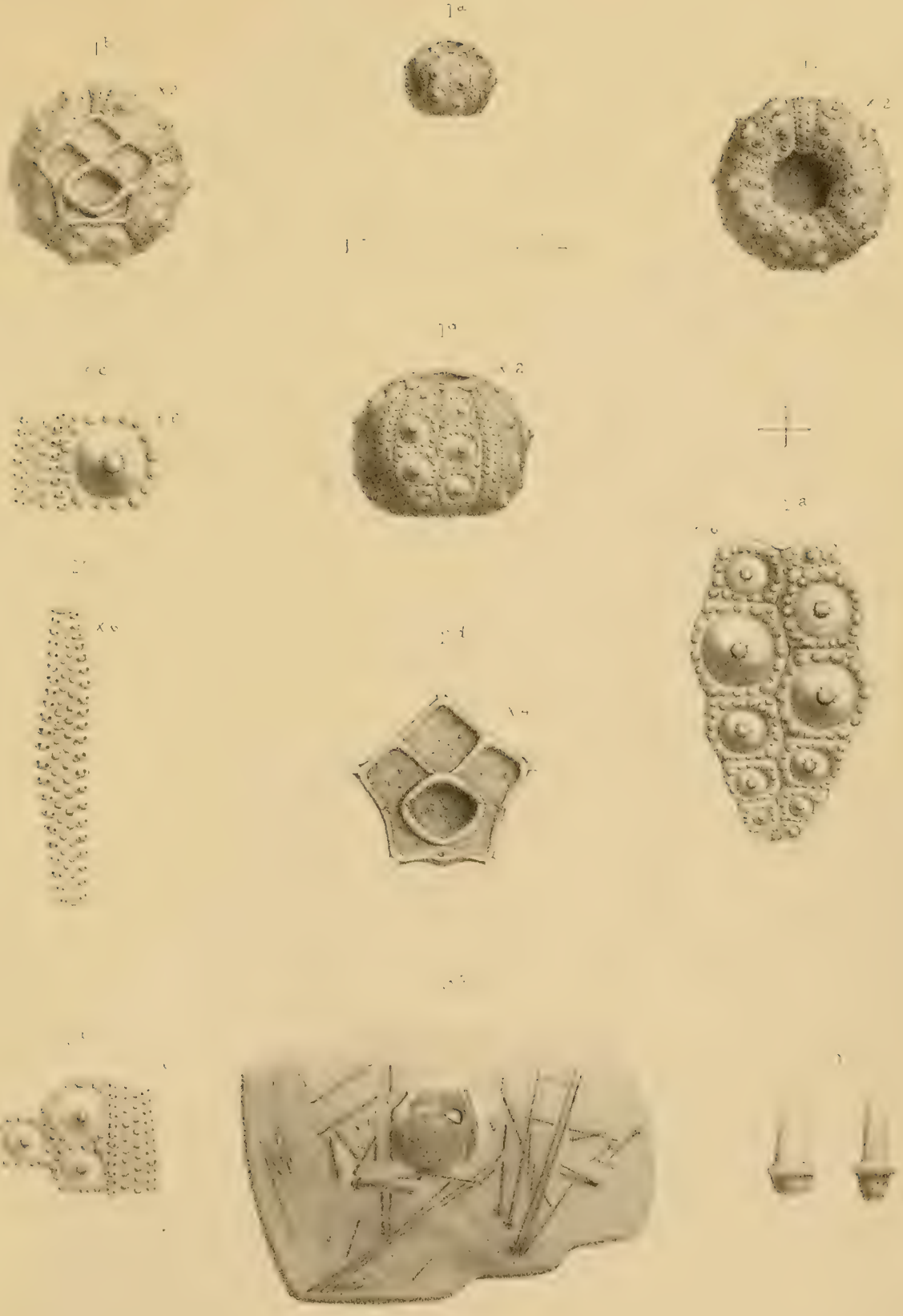


PLATE XXXVII.

From the Lower Grey Chalk.

Fig. 1 *a*. SALENIA AUSTENI, *Forbes*. Test, natural size. British Museum.

1 *b*. ,, ,, Under surface, showing peristome magnified two diameters.

1 *c*. Upper surface, showing disc magnified two diameters.

1 *d*. Lateral view, showing periprocte magnified two diameters.

1 *e*. Inter-ambulacra, entire, magnified four diameters.

1 *f*. Ambulacra, do. do. do.

1 *g*. Single plate of ambulacra, do. six do.

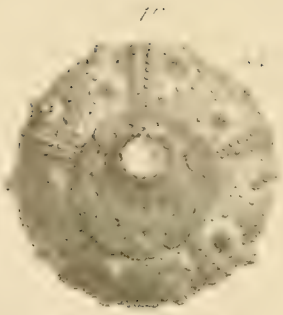
1 *h*. Single tubercle in profile, do. do.

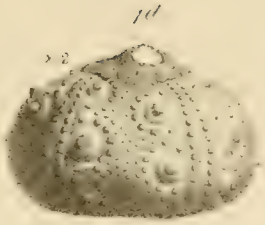
1 *i*. Apical disc detached, do. four do.

Fig. 2. Test, natural size, do. do., Royal School of Mines.

1b
x 2

1a

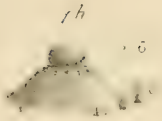

1c

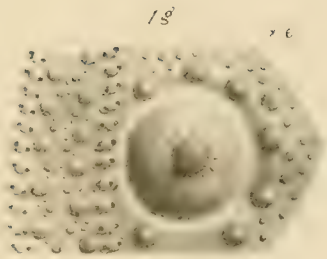

1d
x 2

1e
x 4

2

1f


1h
x 6


1g
x 6

1i
x 4

PLATE XXXVIII.

From the Lower Grey Chalk.

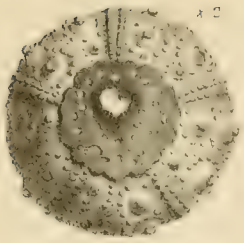
Fig. 1 *a*. Salenia Clarkii, *Forbes*. Test, natural size. British Museum.
1 *b*. ,, ,, Upper surface, showing disc magnified two diameters.
1 *c*. ,, ,, Under do., do. peristome do. do.
1 *d*. ,, ,, Lateral view, showing ambulacral areas and poriferous zones, magnified two diameters.
1 *e*. ,, ,, Apical disc detached, magnified four diameters.
1 *f*. ,, ,, Inter-ambulacra entire, do. do.
1 *g*. ,, ,, Ambulacra entire, do. do.
1 *h*. ,, ,, One plate and ambulacra, do. six do.

Fig. 2 *a*. Salenia, with spines *in situ*, natural size, Royal School of Mines.
2 *b*. ,, do. club-shaped, magnified three times.
2 *c*. ,, do. spatulate do. do.
2 *d*. ,, Base of spine showing lines, &c., do. six do.

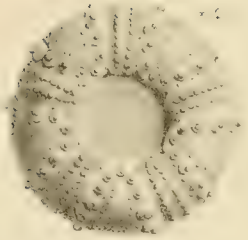
Figs. 3, 4. ,, Bent spines, magnified three times.

1a

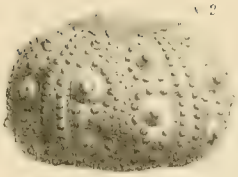
1b



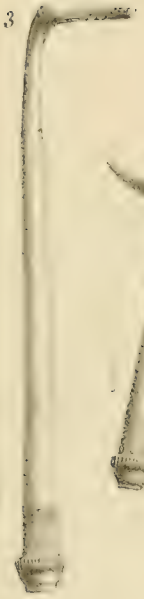
1c



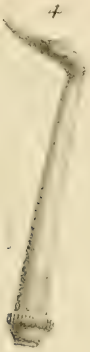
1d



3

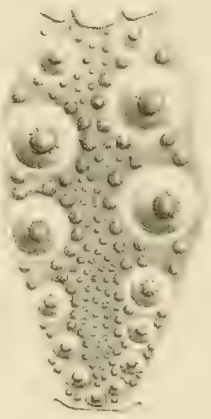


4

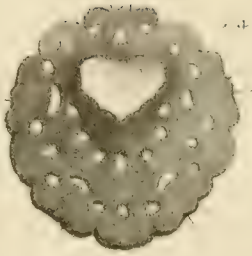


1g

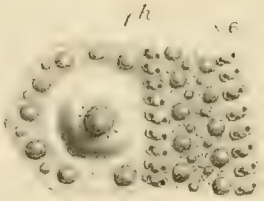
1f



1e



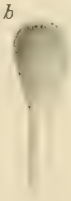
1h



2c

2a

2b



2d

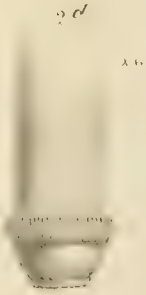


PLATE XXXIX.

From the Lower Chalk.

Fig. 1. Salenia Clarkii, *Forbes.* Apical disc detached, magnified four diameters. The Rev. T. Wiltshire, F.G.S.

Fig. 2 *a.* Salenia Bunburyi, *Forbes.* Test, natural size. Royal School of Mines.

2 *b.* ,, ,, Upper surface, showing disc, magnified two diameters.

2 *c.* ,, ,, Under surface, showing peristome, do. do.

2 *d.* ,, ,, Lateral view, showing sides and periprocte, magnified two diameters.

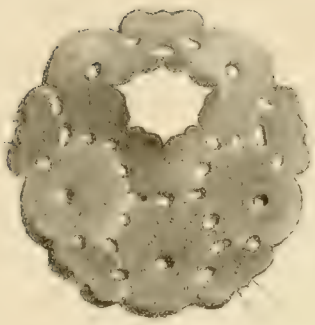
2 *e.* ,, ,, Apical disc detached, magnified four diameters.

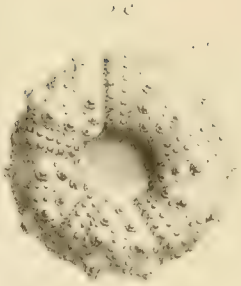
2 *f.* ,, ,, Inter-ambulacra entire, do. do.

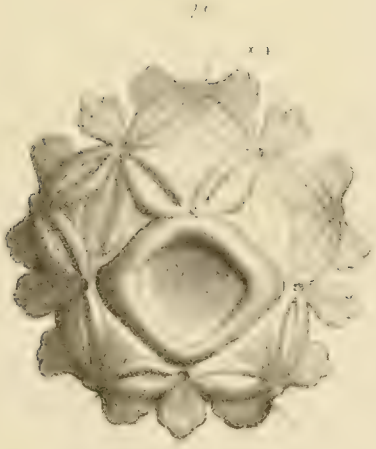
2 *g.* ,, ,, Ambulacra do., do. do.

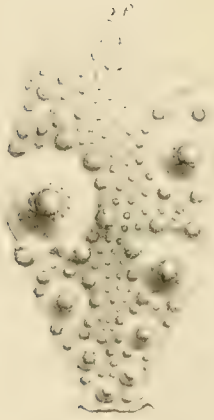
2 *h.* ,, ,, Single plate and ambulacra, do. six do.

2 *i.* ,, ,, Single tubercle do. do.









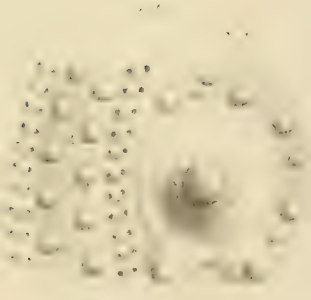


PLATE XL.

From the Red Chalk.

Fig. 1 *a*. PELTASTES WILTSHIREI, *Wright*. Test, natural size. Cabinet of the Rev. T. Wiltshire, F.G.S. (P. 161.)

b. ,, ,, Upper surface, magnified two diameters.

c. ,, ,, Under surface, do. do.

d. ,, ,, Lateral view, do. do.

e. ,, ,, Inter-ambulacral area, magnified four times.

f. ,, ,, Ambulacral area, do. do.

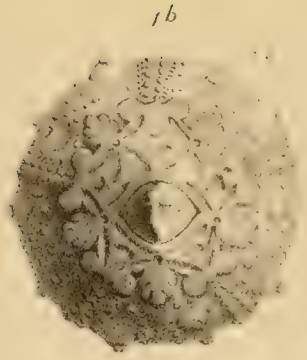
g. ,, ,, Apical disc, do. do.

h. ,, ,, Single plate and portion of ambulacra, magnified six times.

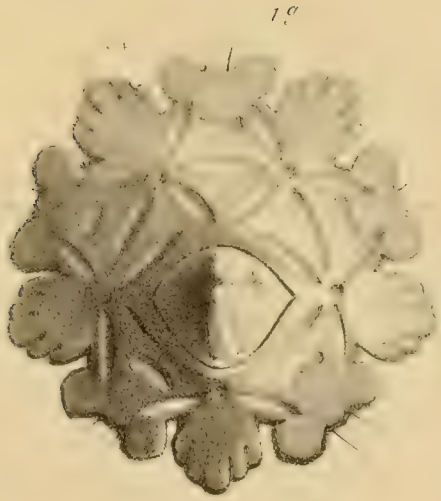
Fig. 2. ,, ,, Mould magnified two diameters.

1c

1a

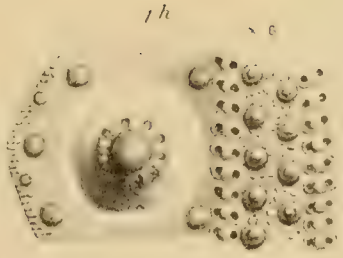

1b

1f


1g

1e

2


1h

1d

C.R.Bone del et lith.

M. & N. Hanhart imp

PLATE XLI.

From the Red Chalk.

Fig. 1 *a*. PELTASTES STELLULATUS, *Agassiz*. Test, natural size. Rev. T. Wiltshire, F.G.S. (P. 153.)

b. ,, ,, Upper surface, magnified two diameters.

c. ,, ,, Lateral view, do. do.

d. ,, ,, Apical disc, do. four times.

e. ,, ,, Inter-ambulacra, do. do.

f. ,, ,, Ambulacra, do. do.

g. ,, ,, Single plate and portion of ambulacra, magnified six times.

From the Lower White Chalk.

Fig. 2 *a*. SALENIA GRANULOSA, *Forbes*. Upper surface, magnified two diameters. The British Museum. (P. 179.)

b. ,, ,, Under surface, magnified two diameters.

c. ,, ,, Lateral view, do. do.

d. ,, ,, Inter-ambulacral area, magnified four times.

e. ,, ,, Ambulacral do. do. do.

f. ,, ,, Single plate and portion of ambulacra, magnified six times.

Fig. 3. ,, ,, Apical disc, magnified four diameters. The Rev. T. Wiltshire, F.G.S.

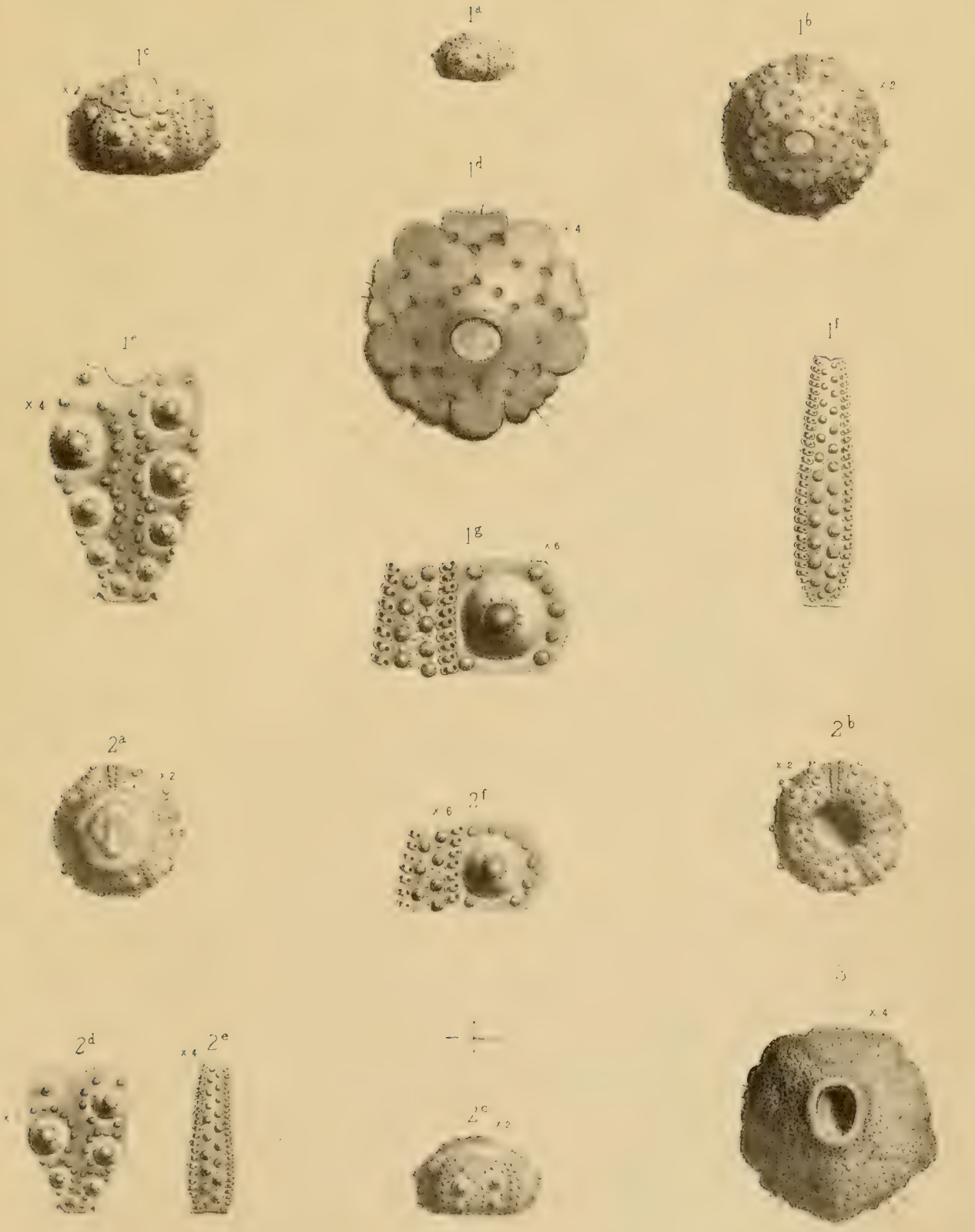

1a
1b
x 2
1c
x 2
1d
x 4
1e
x 4
1f
1g
x 6
2a
x 2
2b
x 2
2c
x 2
2d
2e
x 4
2f
x 6
x 4

PLATE XLII.

Tests with Spines attached.

Fig. 1. SALENIA CLARKII, *Forbes*, with bent spines attached and *in sitû*. Rev. T. Wiltshire, F.G.S. (P. 177).

2 *a*. „ CLARKII, *Forbes*. Test, with bent spines. Rev. T. Wiltshire, F.G.S.

b. „ „ Spine bent near the middle, magnified three times.

c. „ „ Base, showing lines and milled ring, magnified six times.

d. „ „ Section of a spine, magnified six times.

3. „ PETALIFERA ? *Desm*. Test, with spines, natural size. British Museum. (P. 170).

4. „ „ Do. do. do. Rev. T. Wiltshire, F.G.S.

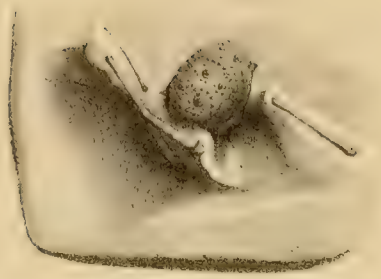
5 *a*. „ CLARKII, *Forbes*. Do. do. do. Royal School of Mines.

b. „ „ Portion of spine, magnified six times.

c. „ „ Do. do. do.

1

2ª

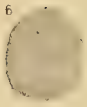


4

3

2ᵈ

x 6



2ᵇ

x 3

5ª

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2ᶜ

x 6

PLATE XLIII.

From the Lower White Chalk.

Fig. 1 *a*. SALENIA GRANULOSA, *Forbes*. Test, natural size. Dr. Bowerbank's Collection, now in the British Museum. (P. 179.)

b. ,, ,, Upper surface, magnified two diameters.

c. ,, ,, Under surface, do. do.

d. ,, ,, Lateral view, do. do.

e. ,, ,, Apical disc, do. four diameters.

f. ,, ,, Inter-ambulacral area, magnified four times.

g. ,, ,, Ambulacral area, do.

h. ,, ,, Single plate and portion of ambulacra, magnified six times.

From the Upper White Chalk.

Fig. 2 *a*. SALENIA GEOMETRICA, *Agassiz*. Test, natural size. British Museum. (P. 182.)

b. ,, ,, Upper surface, magnified two diameters.

c. ,, ,, Lateral view, magnified two diameters.

d. ,, ,, Apical disc, do. four do.

e. ,, ,, Inter-ambulacral area, magnified four diameters.

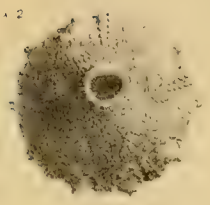
f. ,, ,, Ambulacral area, do. do. do.

g. ,, ,, Single plate and portion of ambulacra, magnified six times.

3 *a*. ,, ,, Mould, *in silex*, a lateral view, natural size. British Museum.

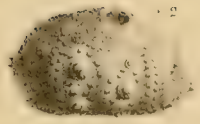
b. ,, ,, Under surface of the same mould, natural size.

1b



1a

d



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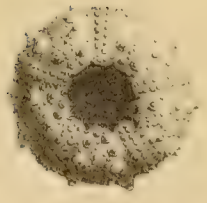
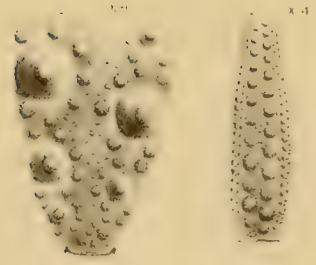


1g



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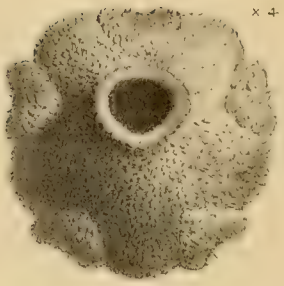
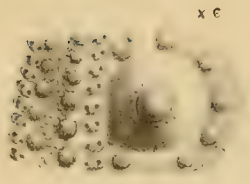
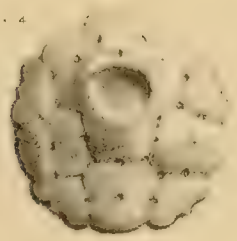




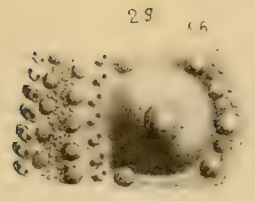
2b

2d



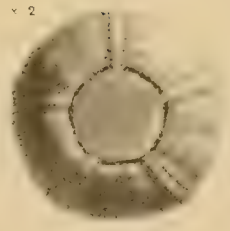
2a

2g



2c

3b



3a

2f

2e

PLATE XLIV.

From the Upper White Chalk.

Fig. 1 *a*. SALENIA MAGNIFICA, *Wright*. Test, natural size. British Museum. (P. 184.)

b, „ „ Upper surface of test, magnified two diameters.

c. „ „ Under surface, do. do.

d. „ „ Lateral view, do. do.

e. „ „ Apical disc, do. four do.

f. „ „ Inter-ambulacral area, do. do.

g. „ „ Ambulacral do. do. do.

h. „ „ Portion of the base of ambulacral and inter-ambulacral areas, magnified six times.

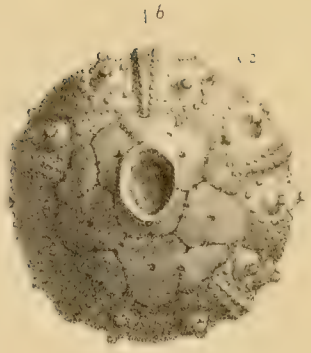
i. „ „ Single plate and portion of ambulacra, magnified six diameters.

k. „ „ Lateral view of a primary tubercle, magnified six times.

l. „ „ Oblong mouth-opening and peristome, magnified four times.

1a

1b



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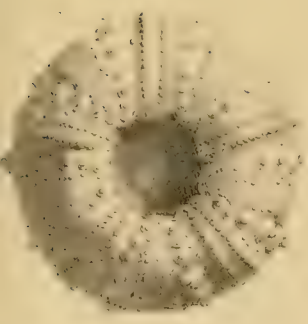
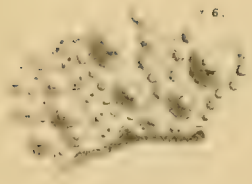


1c

1d

1g

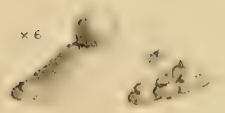
1e



1f

1i

1k



1l

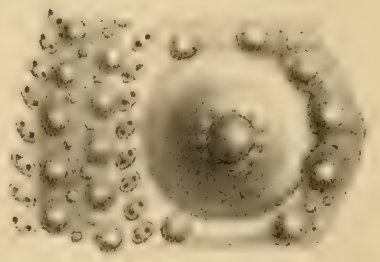


PLATE XLV.

Cottaldia Benettiæ, *König*, 1825.

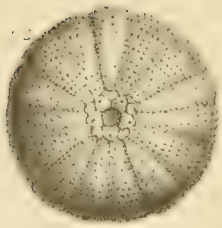
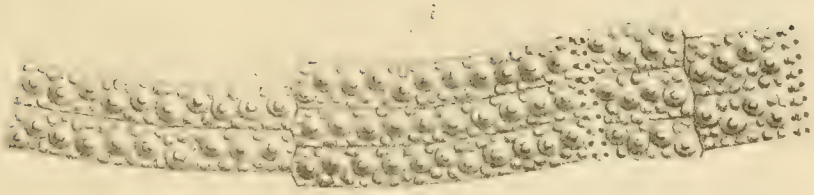
From the Upper Greensand.

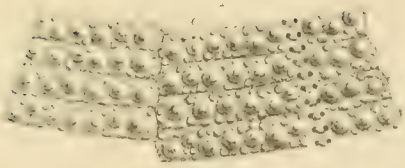
Fig. 1 *a*, 2 *a*, 3. Lateral views of tests, natural size. My collection. (P. 187.)
b. Upper surface of test, showing the apical disc, magnified two diameters. My collection.
c. Under surface of same, showing the base and peristome, do. do.
d. Lateral view of do. do. the lobe-like character of the areas, do.
e. Portion of the inter-ambulacral and ambulacral areas and poriferous zones, showing the linear arrangement of the tubercles on the plates, magnified ten times.
f. Portion of the inter-ambulacral plates and tubercles at the base, magnified ten times.
g. Apical disc complete, do. magnified six times.

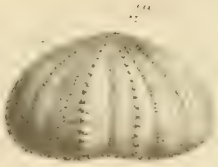
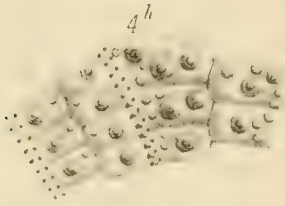
Discoidea subuculus, *Klein*, 1734.

From the Upper Greensand and Grey Chalk.

Fig. 4 *a*. Lateral view of test, the natural size. My collection. (P. 200.)
b. Upper surface of same, magnified two diameters.
c. Under do. do. do. do.
d. Lateral do. do. do. do.
e. Apical disc, magnified twelve times.
f. Upper portion of inter-ambulacral areas, do.
g. Plates of inter-ambulacra, ambulacra, and poriferous zones, magnified eleven times.
h. Do. do. do. do. at base, do. do.
Fig. 5. Large test from the Grey Chalk.
6. Small test, conical variety, do.



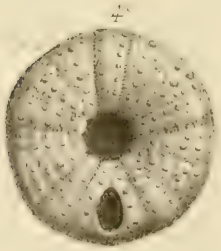


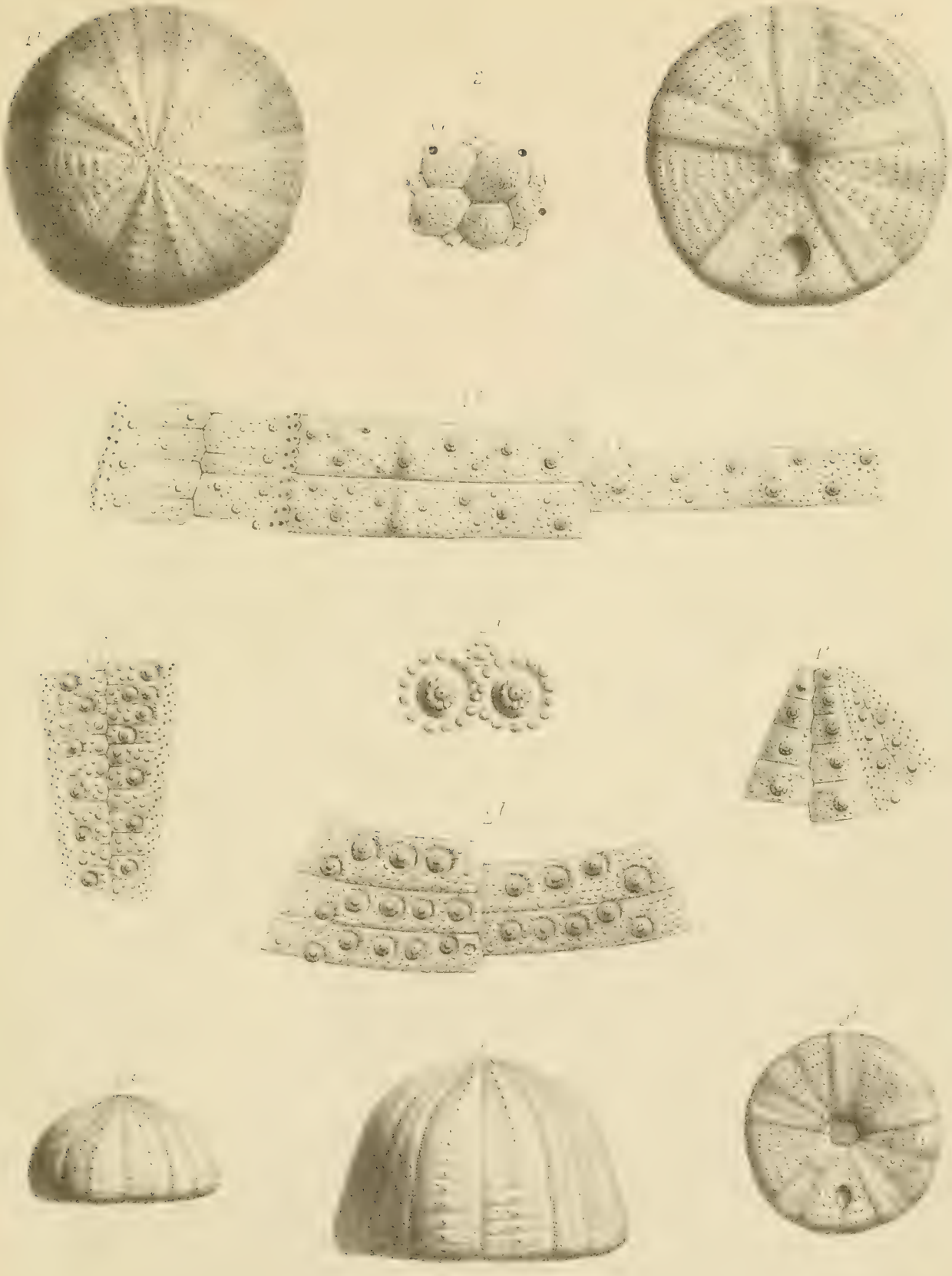
PLATE XLVI.

DISCOIDEA CYLINDRICA, *Lamarck*, 1816.

From the Lower Chalk.

Fig. 1 *a*. Upper surface of a large test, natural size. My collection. (P. 204.)
b. Under do. do. do.
c. Lateral view of another test, from the Chloritic Chalk, natural size.
d. Inter-ambulacral and ambulacral plates, with poriferous zones, and showing distribution of the tubercles, magnified four times.

Fig. 2 *a*. A small test from the Lower Grey Chalk, showing a lobed variety of the same species, lateral view, natural size. My collection.
b. Under surface of the same, do.
c. Apical disc, magnified six times.
d. Primary tubercles, showing detailed structure, highly magnified.
e. Upper portion of the inter-ambulacra, ambulacra, and poriferous zones, magnified six diameters.
f. A portion of the basal ambulacral plates and poriferous zones, magnified six times.
g. A portion of the basal inter-ambulacral do. do. do.



C. R. Bone del. et lith.

M. & N. Hanhart imp.

PLATE XLVII.

Discoidea cylindrica, *Lamarck*, 1816.

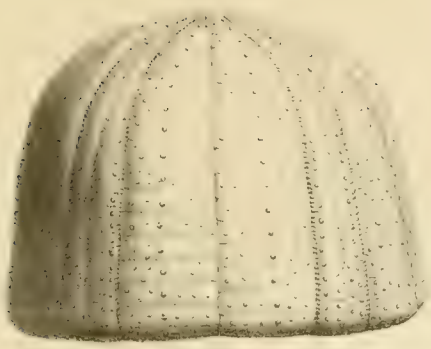
Fig. 1 *a*. Large test, lateral view, natural size. My collection. (P. 204.)
b. Base of the same, do.
2 *a*. Mould showing marginal incisions on the border of the inter-ambulacra.
b. Mould showing the extension of the same at the base.
3. Test wanting anterior single ambulacrum.

Discoidea minima, *Agassiz*, 1840.

Fig. 4 *a*. Upper surface of a test, natural size. (P. 208.)
b. Under surface do. do.
c. Lateral view do. do.
d. Base of do. magnified.
e. Apical disc, greatly magnified.
f. Portion of the inter-ambulacrum, ambulacrum, and poriferous zones, highly magnified.
g. Upper portion of the same parts, highly magnified.
h. The anal plates, highly magnified.

These figures are copied from M. Cotteau's beautiful plate 1012, figs. 1—7, in the 'Palæontologie Française,' tom. vii.

1 a



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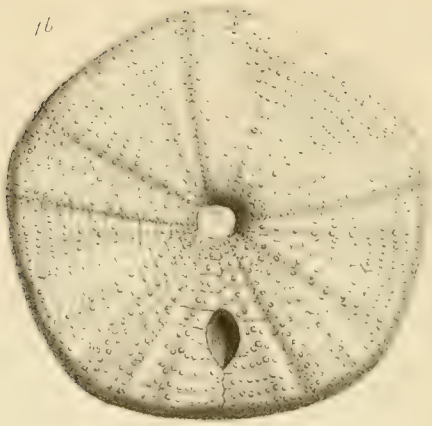
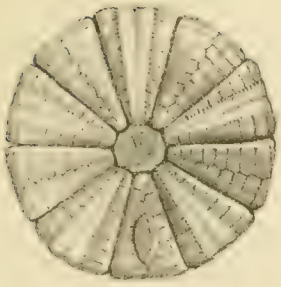


2 b



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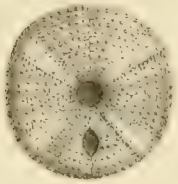

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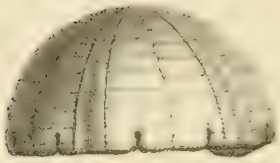
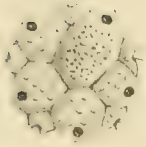


4 f

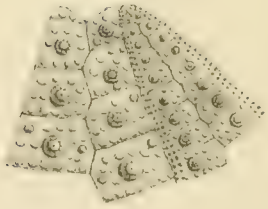


4 c

4 e

4 b

4 a



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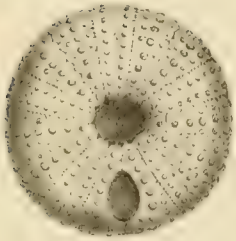
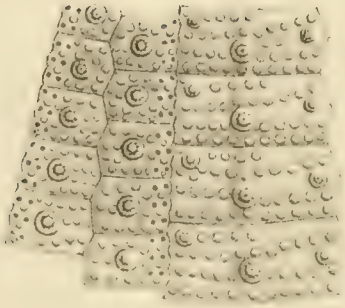


4 g



4 h

M & N Hanhart imp.

del. et lith.

PLATE XLVIII.

Discoidea Favrina, *Desor*, 1842.

From the Upper Greensand.

Fig. 1 *a*. Upper surface of a test, natural size. British Museum. (P. 210.)
b. Base of do. do. do.
c. Lateral view of do. do. do.
d. Apical disc, magnified.
e. Inter-ambulacra, ambulacra, and poriferous zones, magnified four times.
f. Portion of the basal plates of the same parts, do. do.
g. Inter-ambulacral plates, do. do.

Discoidea Dixoni, *Forbes*, 1850.

From the Upper White Chalk.

Fig. 2 *a*. Upper surface, magnified two diameters. My collection. (P. 212.)
b. Lateral view, do. do.
c. Apical disc, highly magnified.
d. Inter-ambulacra, ambulacra, and poriferous zones, magnified six times.
3 *a*. Base of another test, magnified two diameters.
b. Inter-ambulacra, ambulacra, and poriferous zones, magnified eight times.

1c

1a

1b

1e

1d

1f

3b

2c

2d

3a

3a

2b

M.&N. Hanhart imp

PLATE XLIX.

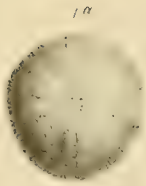
Echinoconus globulus, *Desor*, 1842.

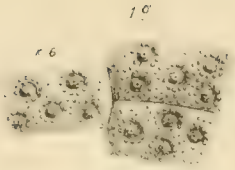
From the Upper Chalk.

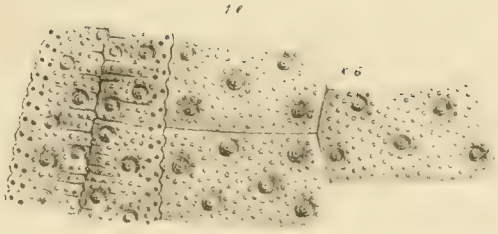
Fig. 1 *a*. Upper surface of a test, natural size. British Museum. (P. 230.)
b. Under do. do. do. do.
c. Lateral view do. do. do.
d. Posterior view do. do. do.
e. Inter-ambulacra, ambulacra, and zones, magnified six diameters.
f. Apical disc, magnified.
g. Tubercles of base.

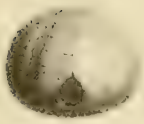
Echinoconus conicus, *Breynius*, 1732.

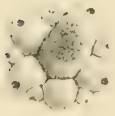
Fig. 2 *a*. Posterior view of a test, natural size. My collection. (P. 221.)
b. Base of the same showing the relative dimensions of vent and peristome.
3. Lateral view of another test.
4. Do. do.
5. Poriferous zones around the periostome, showing the arrangement of triple oblique pairs of pores in that region, magnified four times.

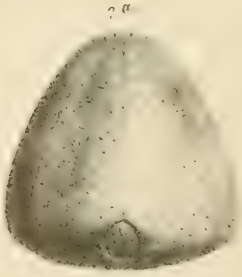


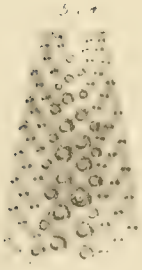












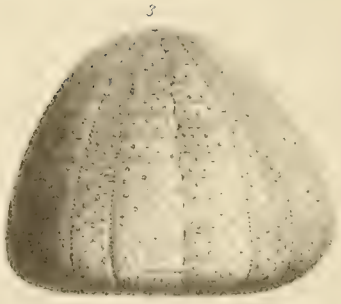
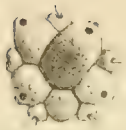


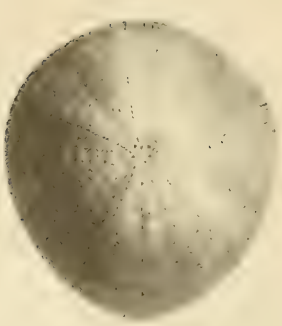
PLATE L.

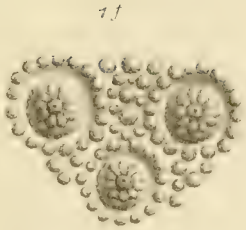
ECHINOCONUS CONICUS, *Breynius*, 1732.

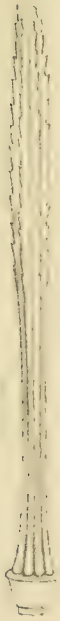
From the Upper Chalk.

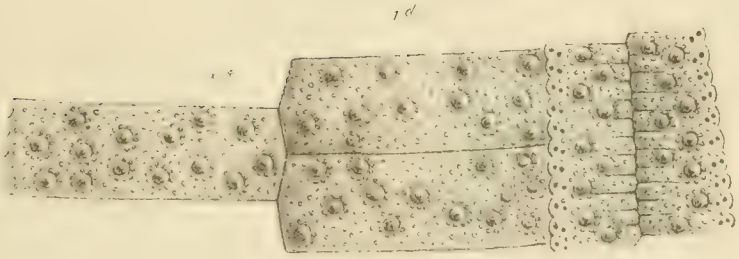
Fig. 1 *a*. Upper surface of test, natural size. My collection. (P. 221.)
b. Under do. do. do.
c. Apical disc, magnified four diameters.
d. Inter-ambulacra, ambulacra, and poriferous zones, magnified four diameters.
e. Do. do. do. near the base, do.
f. Primary tubercles and surrounding granules, highly magnified.
2. Lateral view of a highly conical test.
3. Primary spine, natural size, and highly magnified.
4. Do do. do. do. The Rev. Thos. Wiltshire, F.G.S.
5. Peristome with jaws and teeth *in sitû* do.
6. The jaws and teeth magnified do.
7. Small tubercular spines of the dorso-lateral plates, greatly magnified.

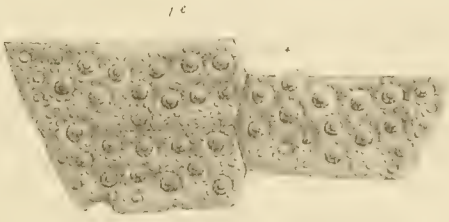


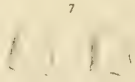


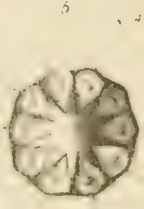












C.R.Bone del. et lith.

M. & N. Hanhart imp.

PLATE LI.

Echinoconus globulus, *Desor*, 1842.

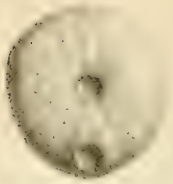
From the Upper Chalk.

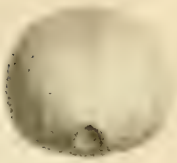
Fig. 1 *a*. Base of the test, natural size. The Rev. T. Wiltshire, F.G.S. (P. 230.)
b. Posterior view do. do. do.
c. Lateral do. do. do. do.

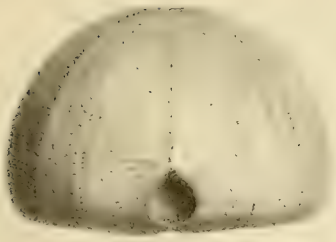
Echinoconus castanea, *Brongniart*, 1842.

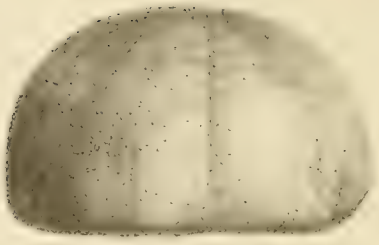
From the Lower Chalk.

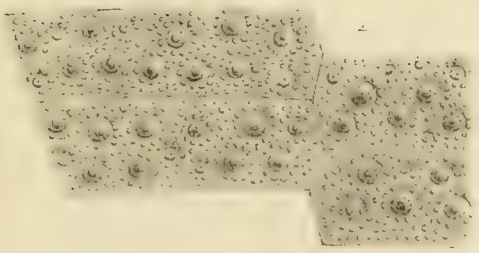
Fig. 2 *a*. Upper surface of a large test, natural size. My collection. (P. 215.)
b. Under do. do. do.
c. Lateral view do. do.
d. Posterior do., showing the position of the marginal vent.
e. Inter-ambulacral and ambulacral plates, and poriferous zone, magnified four diameters.
f. Do. from basal region.
g. Apical disc.
3. A small test of the same species, natural size.

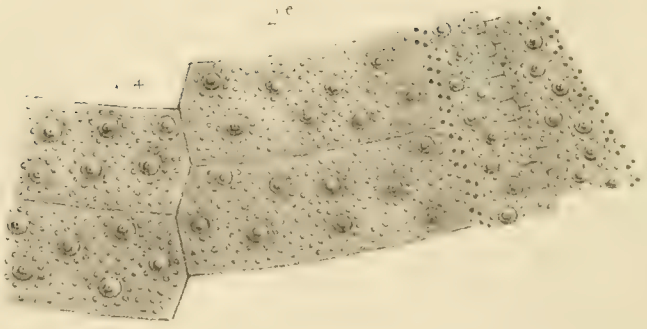


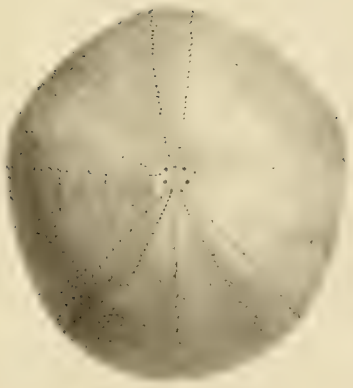


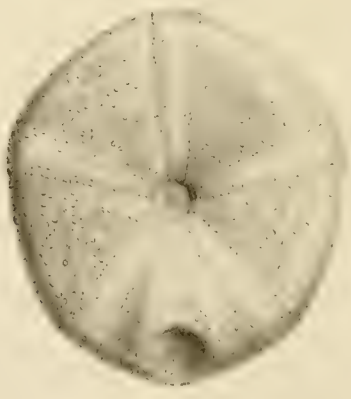












C.R.Bone del et lith.

M&N Hanhart imp

PLATE LII.

Echinoconus subrotundus, *Mantell*, 1822.

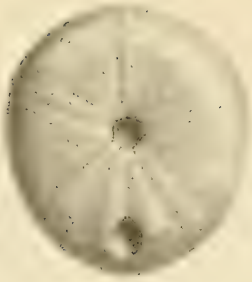
From the Lower Chalk.

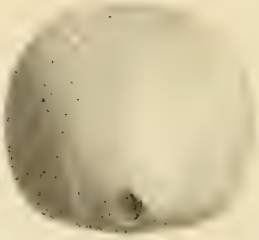
Fig. 1 *a*. Base of test, natural size. Rev. T. Wiltshire, F.G.S. (P. 219.)
c. Lateral view, do.
b. Posterior do. do.
d. Inter-ambulacra, ambulacra, and poriferous zones, magnified four times.
e. Apical disc, do.
f. Portion of the basal plates, do.

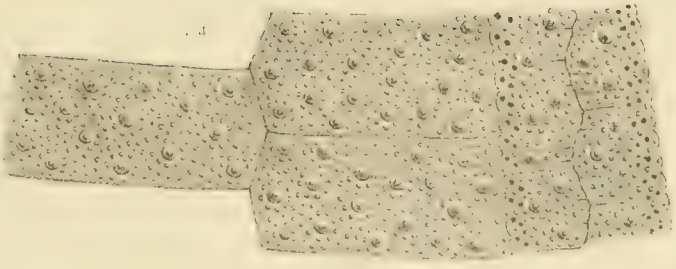
Echinoconus abbreviatus, *Desor*, 1842.

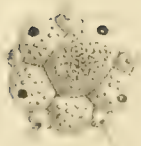
From the Upper Chalk of Norfolk.

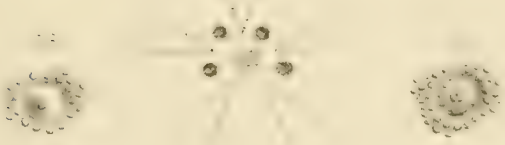
Fig. 2 *a*. Upper surface of the test, natural size. My collection. (P. 226.)
b. Base do. do.
c. Lateral view do. do.
d. Posterior do., with recurved vent.
e. Inter-ambulacra, ambulacra, and zones, magnified four diameters.
f. Portion of the basal plates, do. do.
g. Primary tubercle, magnified.
h. Do. do.
i. Apical disc do.

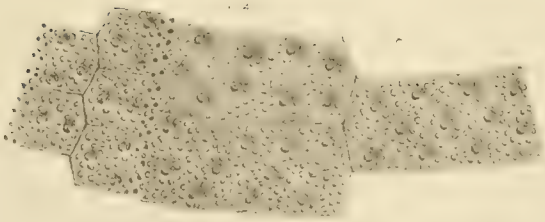


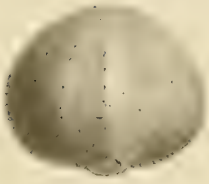












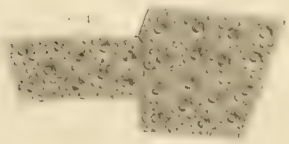


PLATE LIII.

ECHINOCONUS ABBREVIATUS, *Desor.*

From the Upper Chalk.

Fig. 1. Large test, lateral view, natural size. My collection. (P. 226.)

ECHINOCONUS SUBROTUNDUS, *Mantell.*

From the Lower Chalk.

Fig. 2 *a*. Upper surface, natural size. My collection. (P. 219.)
b. Under do. do.
c. Lateral view do.
d. Posterior do. do.
e. Ambulacral and inter-ambulacral plates and poriferous zones, magnified four diameters.
f. Apical disc, highly magnified.
3. Inter-ambulacral basal plates, magnified six diameters.

C R Bone del et lith.

Mintern Bros. imp

PLATE LIV.

Pyrina lævis, *Agassiz.*

From the Upper Greensand.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 238.)
b. Do. do. magnified two diameters.
c. Do. under surface do. do.
d. Do. lateral view do. do.
e. Do. posterior view do. do.

Pyrina Desmoulinsii, *D'Archiac.*

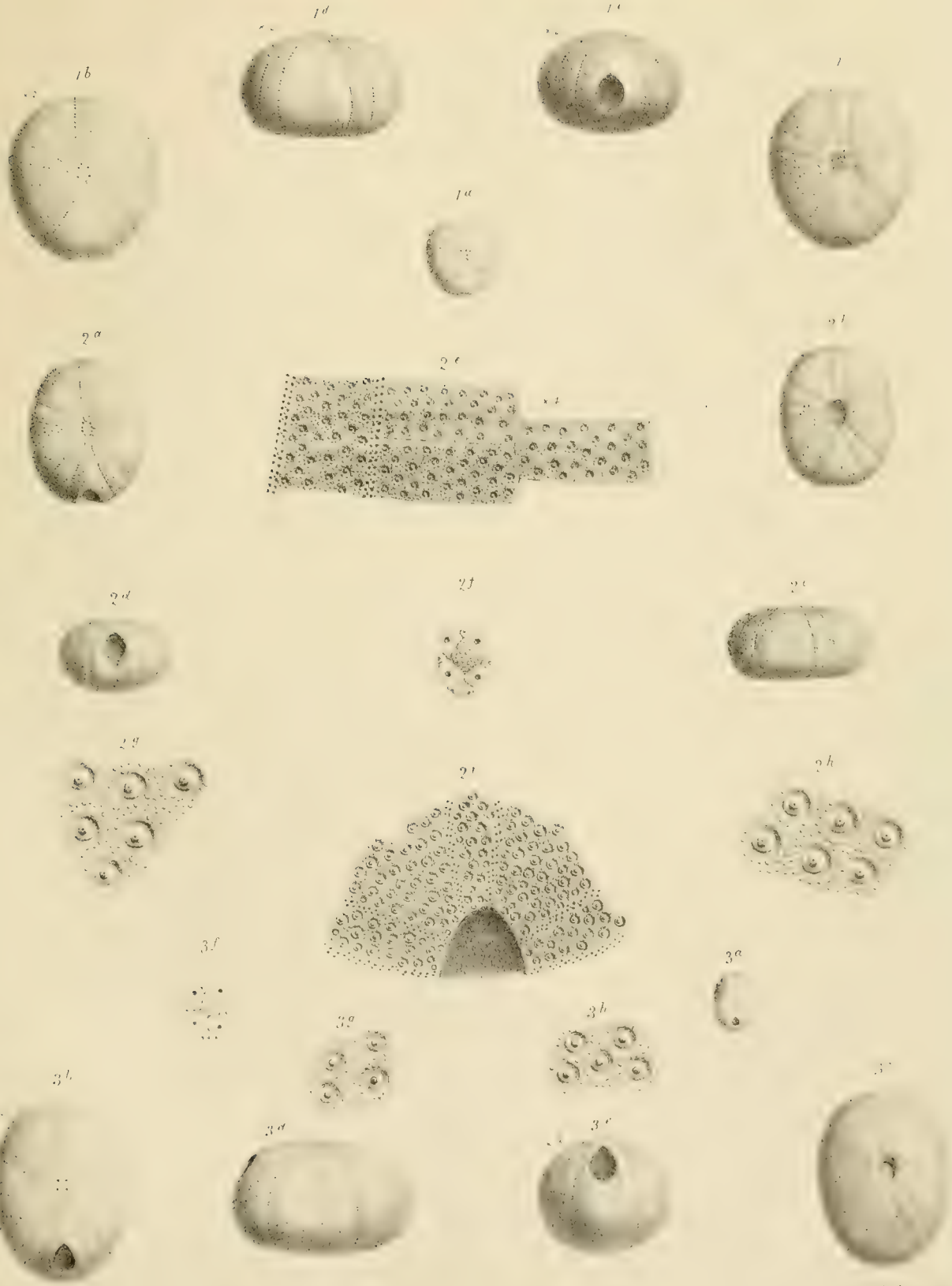
From the Chloritic Marl.

Fig. 2 *a*. Upper surface, natural size My collection. (P. 236.)
b. Under do. do.
c. Lateral view do.
d. Posterior do. do.
e. Ambulacral and inter-ambulacral plates and poriferous zones, magnified four diameters.
f. Apical disc, highly magnified.
g, *h*, *i*. Various forms of basal tubercles, highly magnified.

Pyrina ovulum, *Lamarck.*

From the Upper Greensand.

Fig. 3 *a*. Test, upper surface, natural size. Royal School of Mines. (P. 237.)
b. Do. do. magnified three diameters.
c. Do. under surface do. do.
d. Do. lateral view do. do.
e. Do. posterior do. do. do.
f. Apical disc, highly magnified.
g. Plates, tubercles, and granules, highly magnified.
h. Do. do. do. do.



C.R.Bone del et lith

M & N Hanhart imp

PLATE LV.

Catopygus Vectensis, *Wright*, nov. sp.

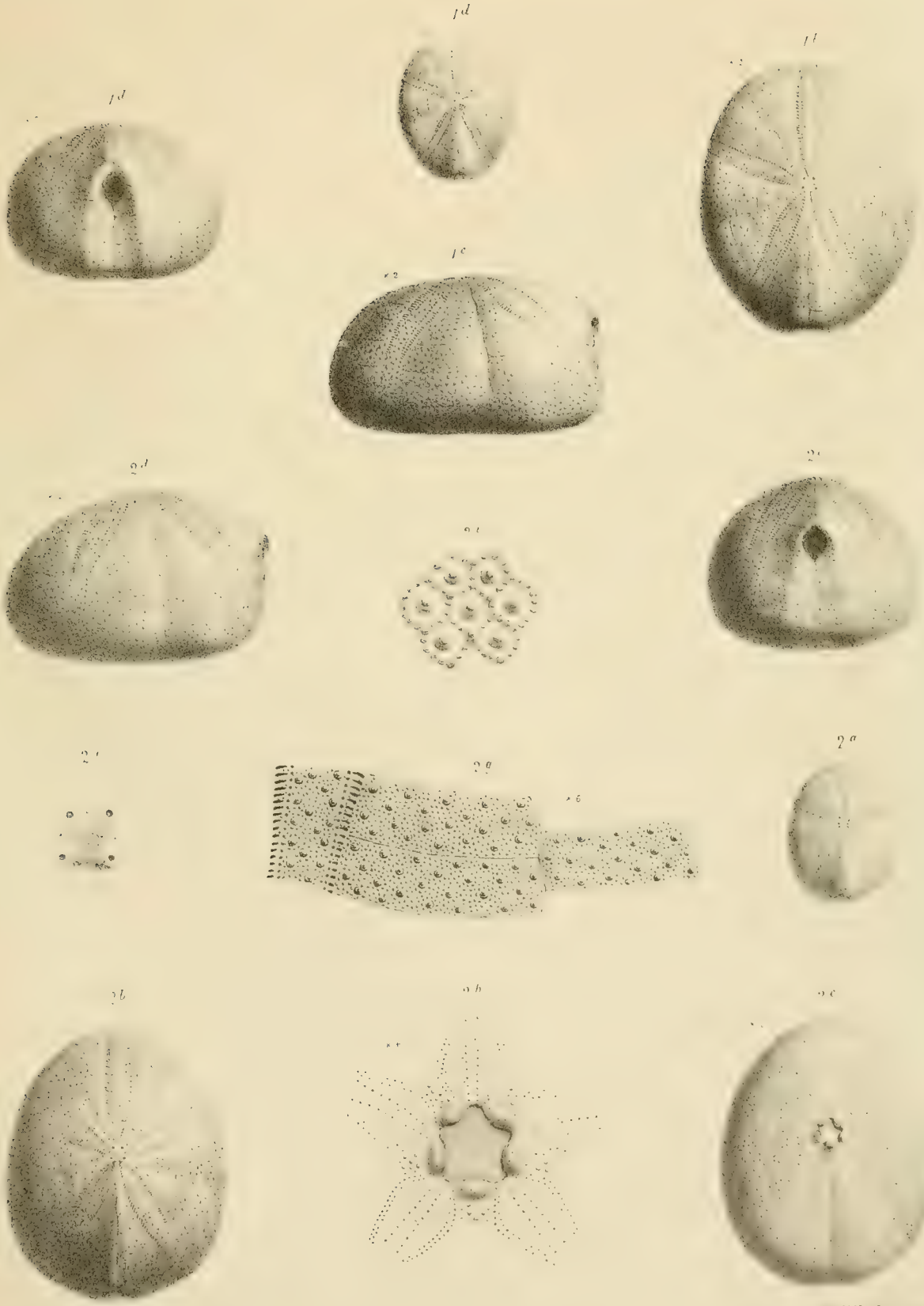
Lower Greensand.

Fig. 1 *a*. Test, natural size, upper surface. Rev. T. Wiltshire, F.G.S., and my collection. (P. 245.)
b. Do. magnified two diameters.
c. Do. lateral view, magnified two diameters.
d. Do. posterior do. do. do.

Catopygus columbarius, *Lamarck*.

From the Upper Greensand.

Fig. 2 *a*. Test, upper surface, natural size. My collection. (P. 241.)
b. Do. do. magnified two diameters.
c. Do. under surface do. do.
d. Do. lateral view do. do.
e. Do. posterior do. do. do.
f. Apical disc, largely magnified.
g. Ambulacral and inter-ambulacral plates, with poriferous zones, magnified six diameters.
h. Mouth, oral lobes, and peristomal rosette around the opening, magnified six diameters.
i. Tubercles from the base highly magnified.



CR Bone del et lith

PLATE LVI.

CLYPEOPYGUS FITTONI, *Wright*, nov. sp.

From the Lower Greensand.

Fig. 1 *a*. Length of the test, natural size. Rev. T. Wiltshire, and my collection. (P. 247.)

b. Upper surface, magnified two diameters.

c. Under do. do. do.

d. Lateral view do. do.

e. Posterior do. do. do.

f. Ambulacral plates and poriferous zones, magnified six times.

2 *a*. Test of another specimen, natural size.

3 *a*. Length of do. do.

b. Upper surface, magnified two diameters.

c. Under do. do. do.

d. Posterior do. do. do.

e. Lateral do. do. do.

f. Ambulacral plates and zones, magnified.

g. Basal tubercles of this form are found near the peristome.

Fig. 4. Another test, natural size.

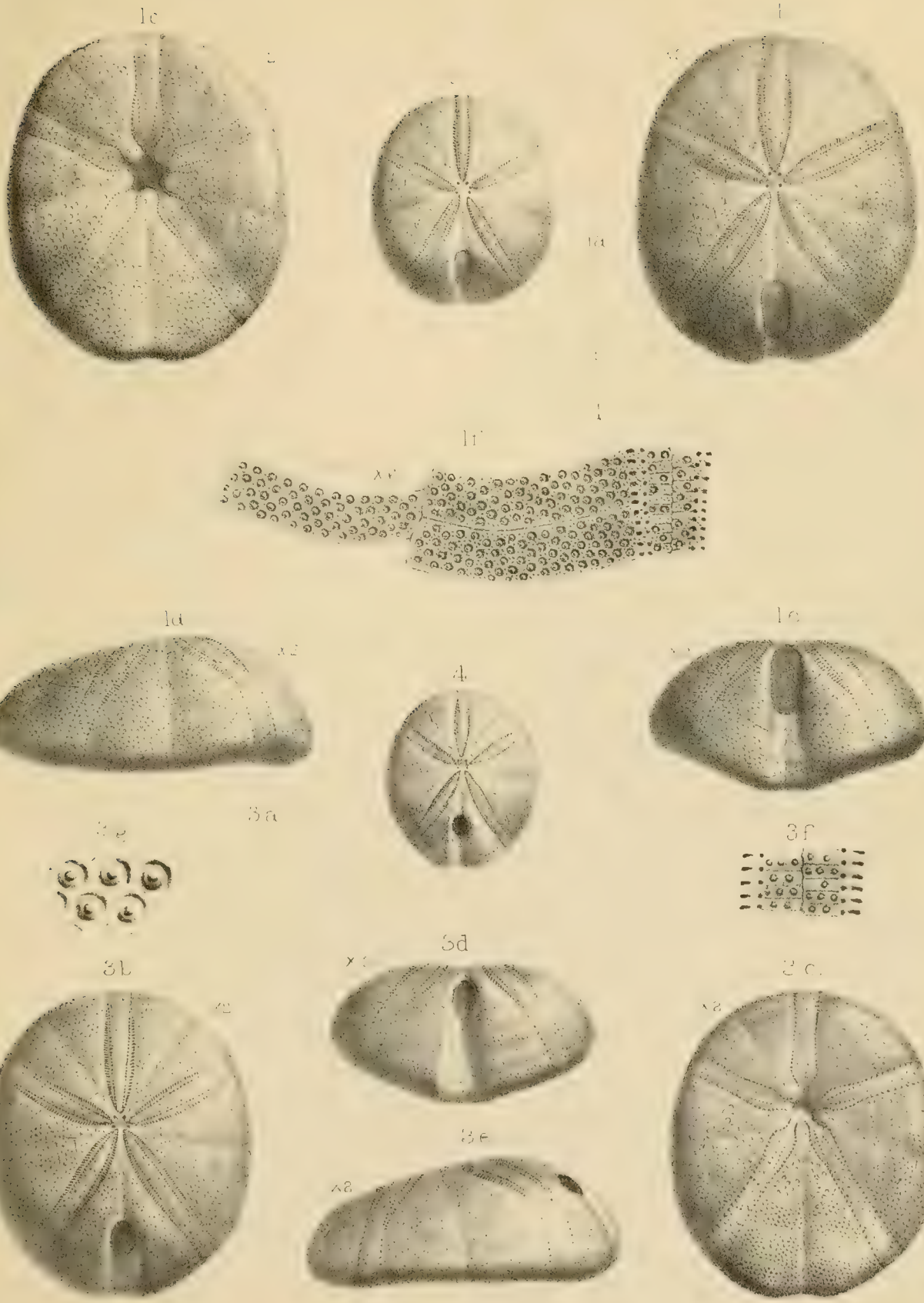

1c
1
1a
1f
1d
1e
4
3a
3f
3d
3b
3c
3e

PLATE LVII.

Trematopygus Faringdonensis, *Wright.*

From the Lower Greensand.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 253.)
b. Do. do. magnified one and a half times.
c. Do. do. do. do.
d. Do. lateral view do. one half.
e. Do. posterior do. do. do.
f. Apical disc, magnified.
g. Ambulacral and inter-ambulacral plates and poriferous zones, magnified six times.
h. Basal tubercles, showing structural details.

Caratomus rostratus, *Agassiz.*

From the Upper Greensand.

Fig. 2 *a*. Vertical line, showing natural size. (P. 255.)
b. Upper surface, magnified six diameters.
c. Under do. do. do.
d. Posterior do. do. do.
e. Lateral view do. do.

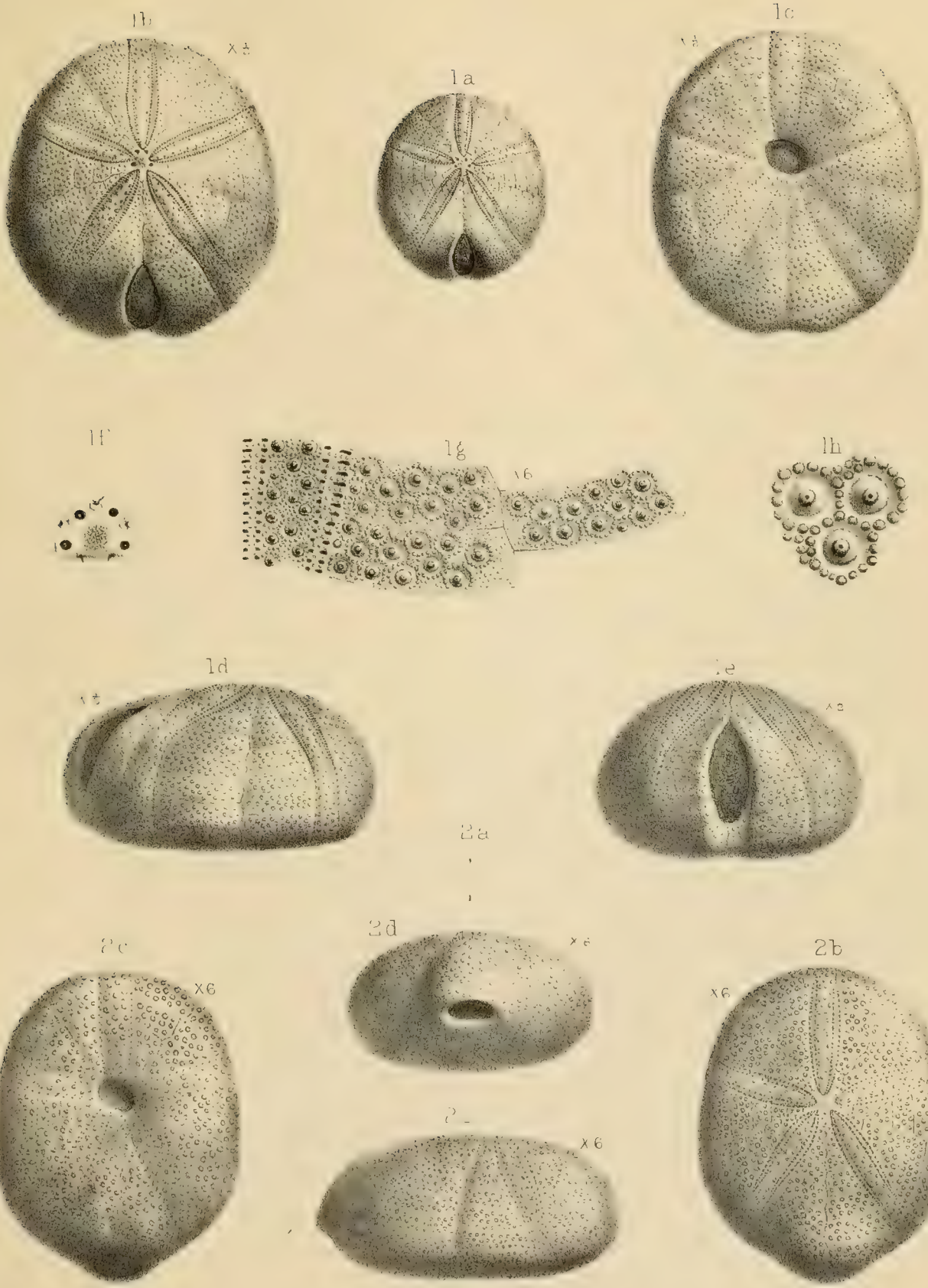
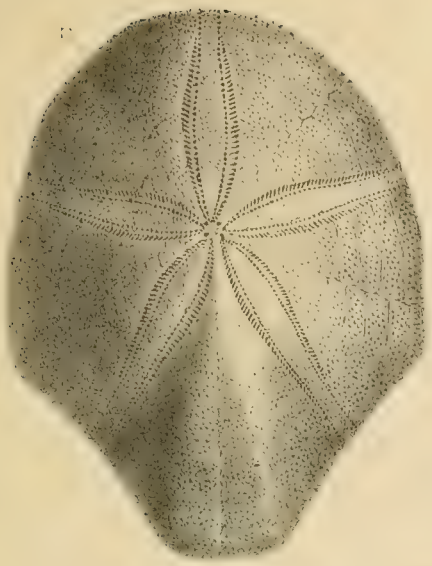

1b
1a
1c
1f
1g
1h
1d
1e
2a
2c
2d
2b

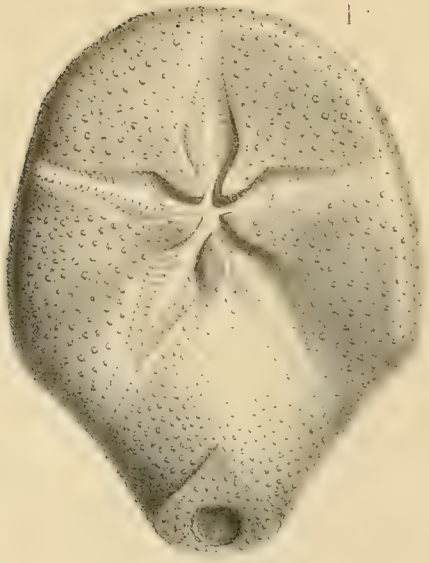
PLATE LVIII.

PYGURUS LAMPAS, *De la Beche.*

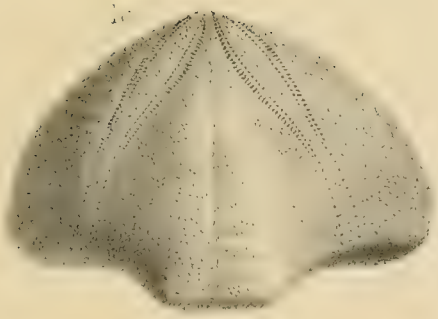
From the Upper Greensand.

Fig. 1 *a.* Test, upper surface, natural size. British Museum. (P. 258.)
b. Do. do. magnified one and a half times.
c. Do. under surface do. do.
d. Do. lateral view do. do.
e. Do. posterior do. do. do.
f. Do. anterior view of the front of the test, magnified one and a half times.
g. Ambulacral and inter-ambulacral plates, with poriferous zones, magnified six times.

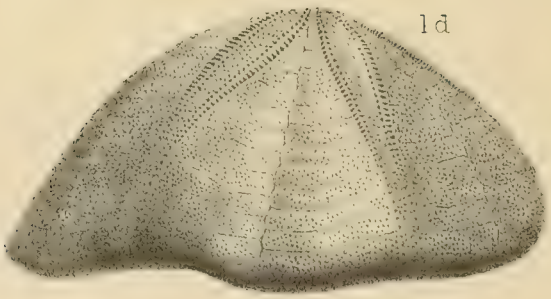


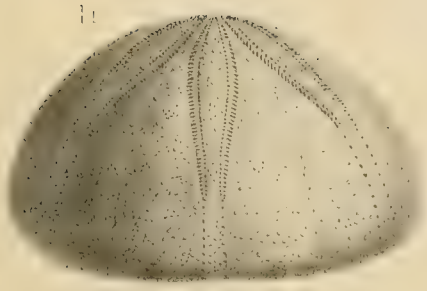


1a



1d





1e

1c

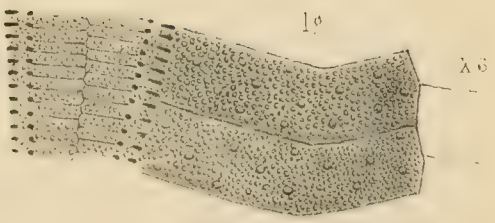


PLATE LIX.

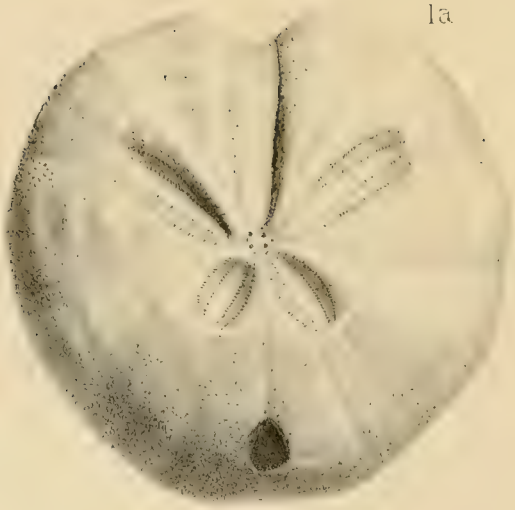
Epiaster De Loriolii, *Wright.*

From the Upper Greensand.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 265.)
b. Do. under do. do.
c. Do. lateral view do.
d. Do. posterior do. do.
e. Do. anterior do. do.
f. Ambulacral and inter-ambulacral plates, with poriferous zones, magnified three times.
g. Apical disc, magnified three times.

1b

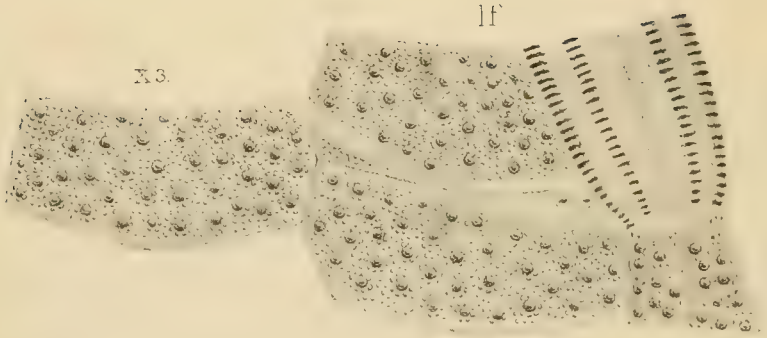
1a



1g

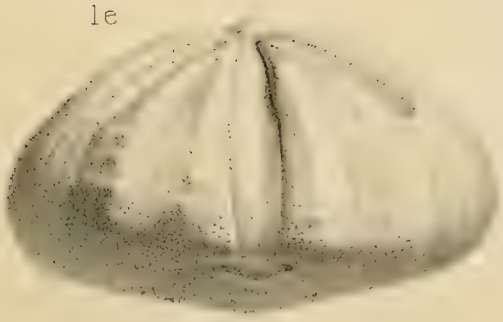
1f

X 3.



1c

1e



1d

PLATE LX.

Echinospatagus Murchisonianus, *Mantell.*

From the Upper Greensand.

Fig. 1 *a*. Test, upper surface, natural size. British Museum.
b. Do. under do. do.
c. Do. lateral view do.
d. Do. posterior do. do.
e. Apical disc, magnified.
f. Plates with tubercles, the fasciole an artist's mistake.
g. Skeleton structure of the ambulacra and poriferous zones and apical disc.
h. Structure of the anteal ambulacrum.
i. Tubercles, boss, and encircling granules, magnified.

Hemiaster Bailyi, *Forbes.*

From the Gault.

Fig. 2. Test, natural size. Royal School of Mines. (P. 264.)

Hemiaster asterias, *Forbes.*

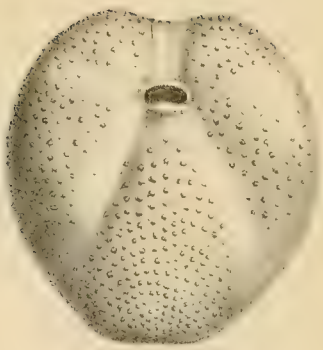
From the Gault.

Fig. 3. Test, natural size. Royal School of Mines. (P. 264.)

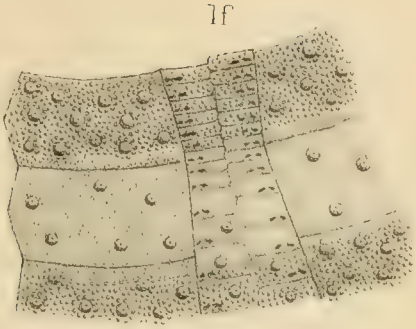
1a

1g

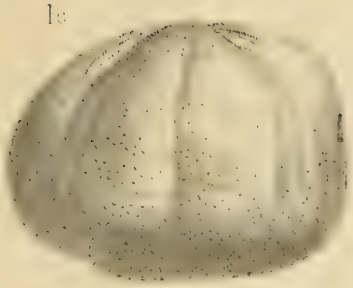
1b



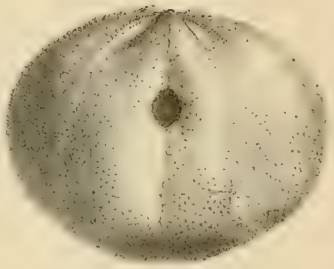
1f



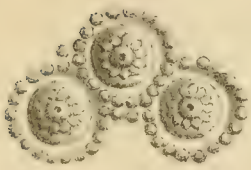
1c



1d



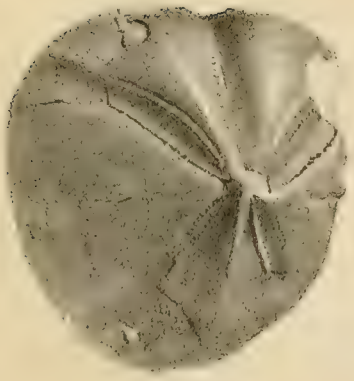
1h



1h

1e

2



3

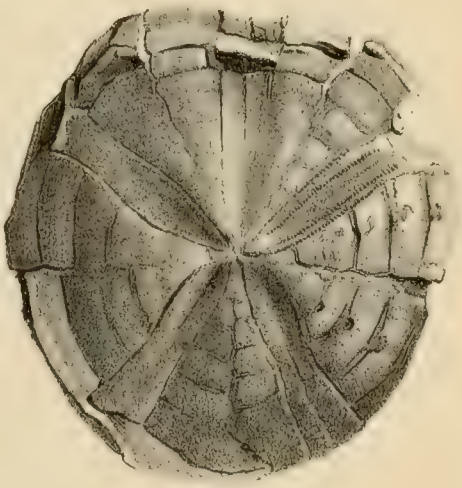


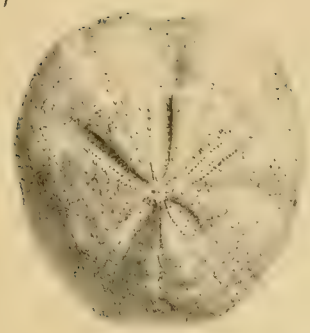
PLATE LXI.

Hemiaster Morrisii, *Forbes.*

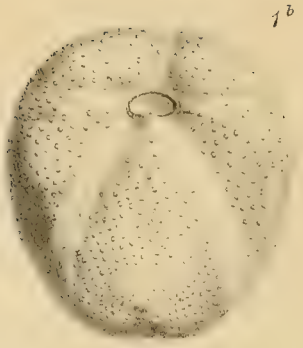
From the Grey Chalk.

Fig. 1 *a*. Test, upper surface, natural size. My collection. (P. 2 62
b. Do. under do. do.
c. Do. lateral view do.
Do. posterior do. do.
e. Do. anterior do. do.
f. Apical disc, magnified.
g. Portion of the dorsal plates, showing the peripetal fasciole, magnified.
h. Ambulacral and inter-ambulacral plates, magnified three times.
i. Tubercles and granules on the upper surface, magnified.
k. Tubercles and granules on the under surface do.

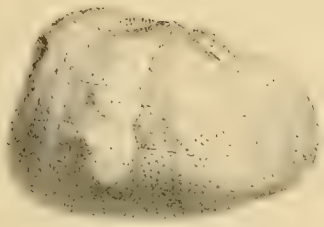
1a



1b



1c

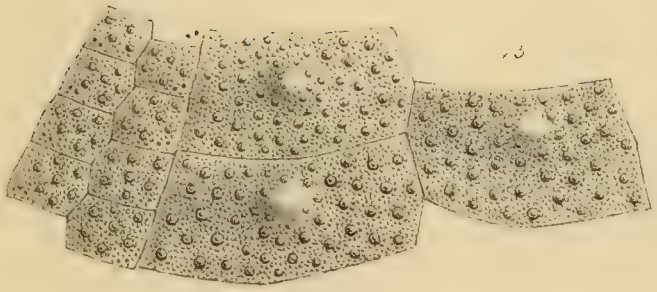


1f

1i

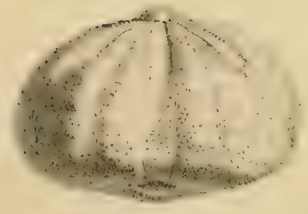
1g

1h

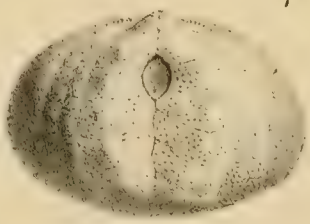


1k

1e



1d



C. R. Bone del. et lith.

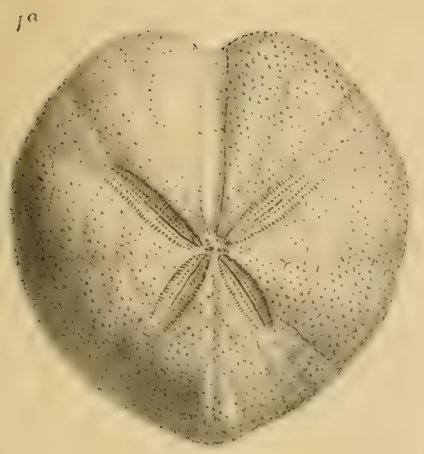
W. West & Co imp.

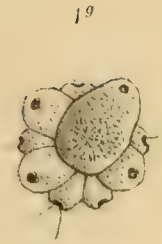
PLATE LXII.

MICRASTER COR-ANGUINUM, *Klein*.

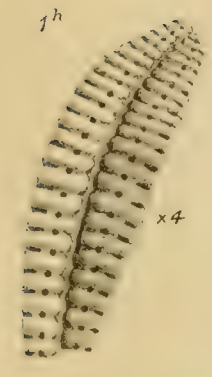
From the Upper Chalk.

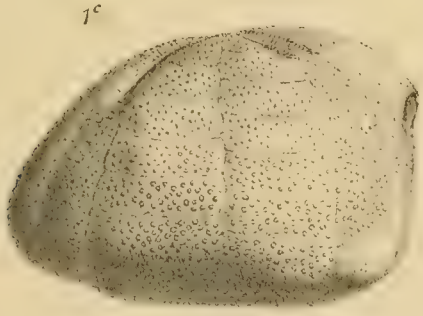
Fig. 1 *a*. Test, upper surface, natural size. My collection.
b. Do. under do. do.
c. Do. lateral view do.
d. Do. posterior do. do.
e. Do. anterior do. do.
f. Ambulacral and inter-ambulacral plates, magnified three times.
g. Apical disc, highly magnified.
h. Lateral ambulacra, magnified four diameters.
i. Anterior single ambulacrum, magnified four diameters.
k. Structure of the sub-anal fasciole, magnified.
l. Structure of tubercles, bosses, and granules, magnified.
Fig. 3. Portion of a spine adherent to the test do.
Fig. 4. Do. do. do. do.
Fig. 5. Spine found on the test do.


1a

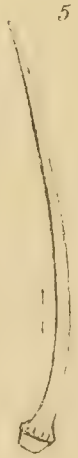

1g

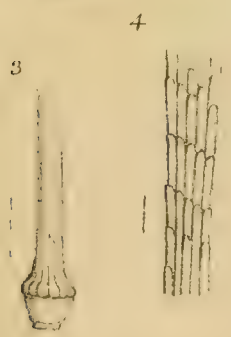
1b

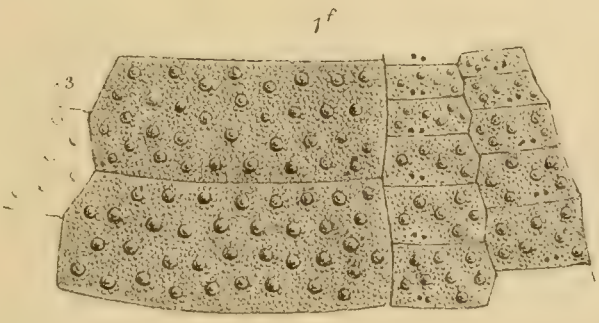

1h
x4

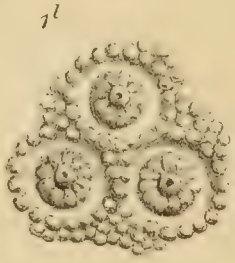

1c

1i
x4


5


4
3


1f
3


1l

1e

1k

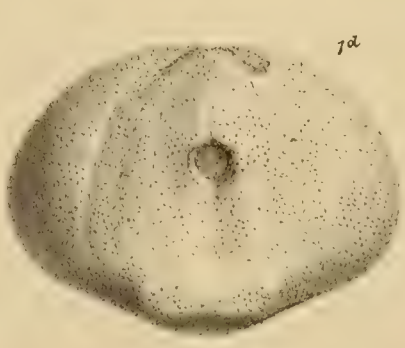

1d

PLATE LXII A.

MICRASTER COR-BOVIS, *Forbes.*

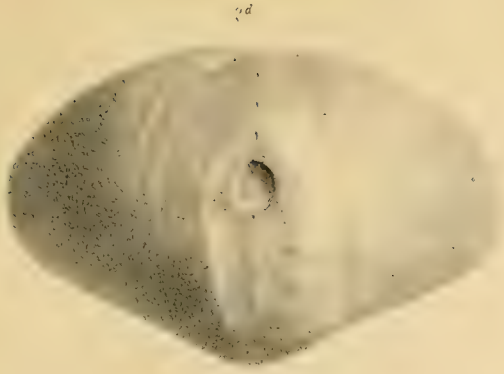
From the Upper White Chalk.

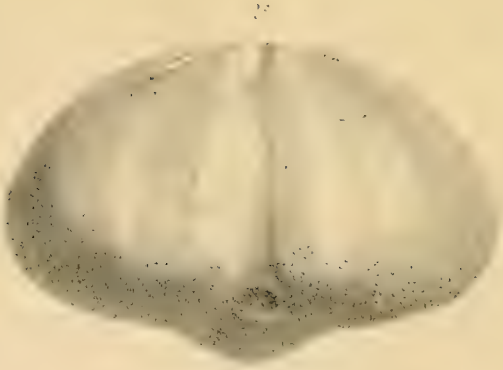
Fig. 1. Base of large test, natural size. British Museum. (P. 276.)
2 *a*. Upper surface do.
b. Lateral view do. do.
c. Anterior border, anteal sulcus, and mouth opening.
d. Posterior border, with vent and periprocte.

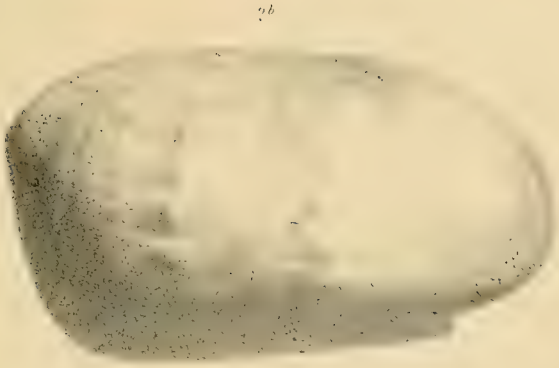
MICRASTER BREVIPORUS, *Agassiz.*

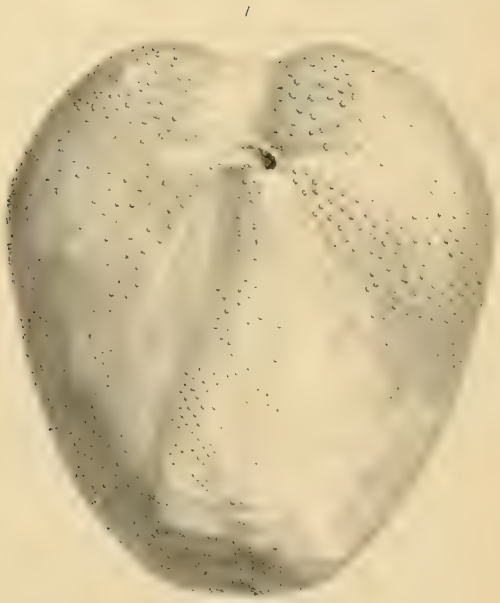
From the Upper White Chalk.

Fig. 3 *a*. Upper surface, natural size. My collection. (P. 278.)
b. Under do. do.









C R Bone del et lith

Vincent Brooks Day & Son Imp

PLATE LXIII.

EPIASTER GIBBUS, *Lamarck.*

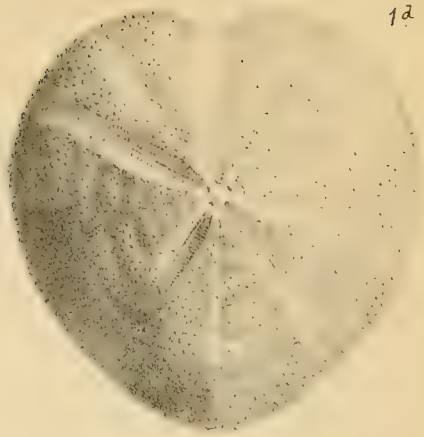
From the Upper White Chalk.

Fig. 1 *a.* Upper surface, natural size. My collection. (P. 267.)
b. Under do. do.
c. Lateral do. do.
d. Posterior do. do.
e. Anterior do. do.
f. Apical disc, magnified four diameters.
g. Ambulacral and inter-ambulacral plates, magnified three times.
h. Structure of the poriferous zones, magnified.
i. Primary tubercles on upper surface do.
k. Do. do. from basal do. do.

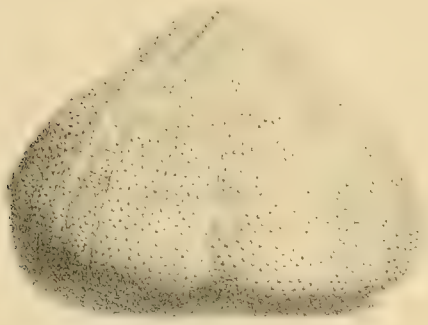
1b

1f

1d



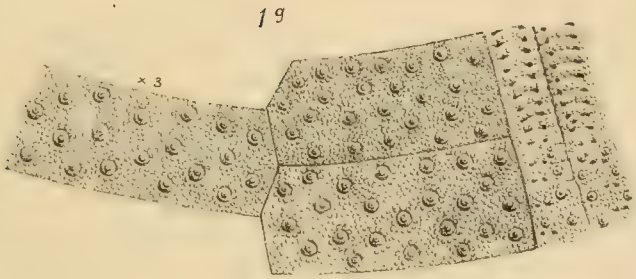
1c



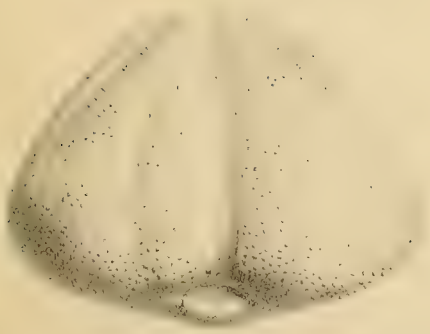
1k

1i

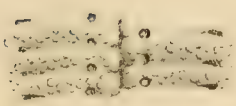
1g



1e



1h



1d

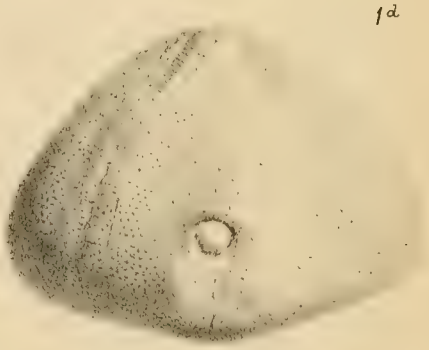


PLATE LXIV.

Echinospatagus Murchisonianus, *Mantell.*

From the Upper Greensand.

Fig. 1. Test, upper surface, natural size. My collection. (P. 281.)

Enallaster Greenovii, *Forbes.*

From the Upper Greensand.

Fig. 2 *a*. Upper surface, natural size. Royal School of Mines. (P. 290.)
b. Under do. do.
c. Posterior do. do.
d. Anterior do. do.
e. Lateral do. do.
f. Apical disc and structure of ambulacra, magnified.
3 *a*. Smaller test, lateral view.
b. Plates, with tubercles from upper surface, magnified.
c. Tubercles from under surface, do. do.
d. Do. do.

Echinospatagus Collegnii, *Sismonda.*

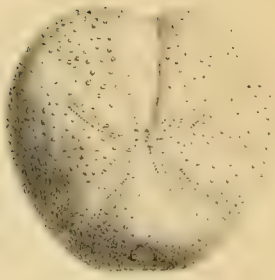
From the Upper Greensand.

Fig. 4. Test, upper surface, natural size. My Collection. (P. 283.)

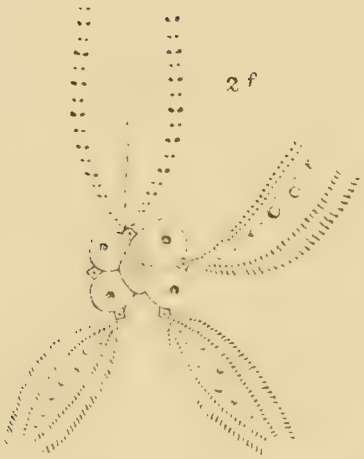
1

2 b

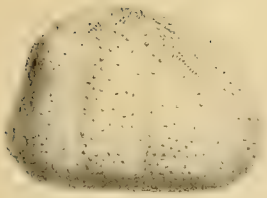
2 a



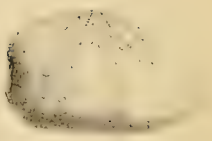
2 f



2 e

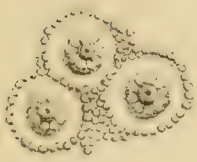


3 a

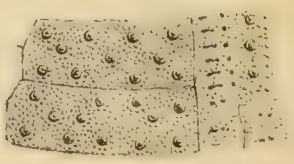


3 c

3 d

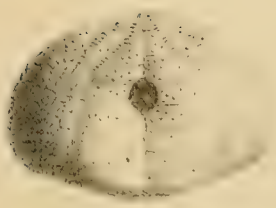


3 b

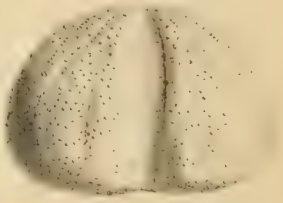


4

2 c



2 d



C.R.Bone, del. et lith.

W.West & Cº imp.

PLATE LXV.

Enallaster Fittoni, *Forbes.*

From the Lower Greensand.

Fig. 1 *a*. Upper surface, natural size. Royal School of Mines. (P. 288.)
b. Under do. do.
c. Lateral do. do.
e. Anterior do. do.
f. Portion of dorsal plates and tubercles, magnified three times.
Fig. 2 *a*. Upper surface of test, natural size. My collection.
b. Apical disc and single ambulacrum, magnified.
c. Anterior petaloid ambulacrum, showing poriferous zones.

Holectypus bistriatus, *Wright.*

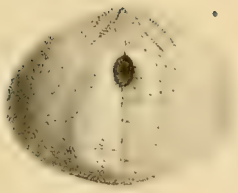
From Chloritic Marl of Chard.

Fig. 3 *a*. Test, upper surface, natural size. My collection. (P. 233.)
b. Lateral view, do.
c. Structure of an ambulacrum, showing the bistriated marginal arrangement.

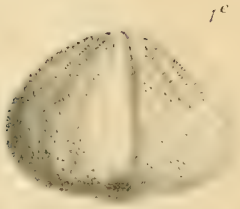
1a

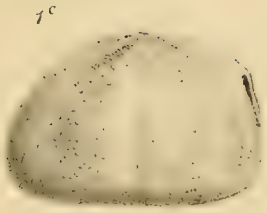
2b

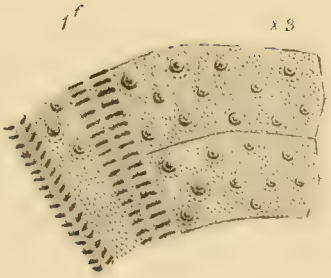
1b


1d

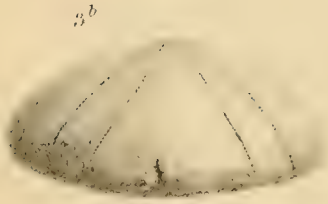
2c


1c


1e


1f ×3

2a


3b

3a

×2 3c

PLATE LXVI.

Goniopygus delphinensis, *Albin Gras.*

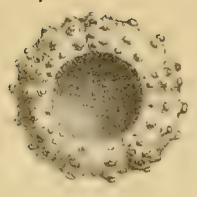
From the Farringdon Sponge Bed, Lower Greensand.

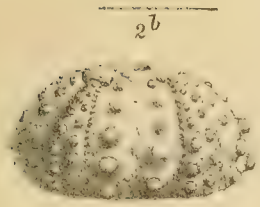
Fig. 1 *a*. Upper surface, natural size. My cabinet.
b. Under do. do.
c. Lateral do. do.
d. Interambulacrum, magnified four times.
e. Ambulacrum, do. do.
f. Apical disc, do. three times.
g. Ambulacral plates, do. six times.

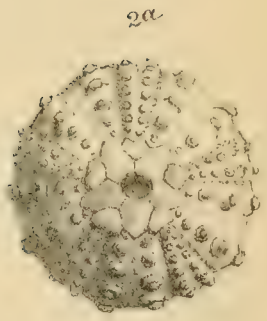
Cardiaster Benstedi, *Forbes.*

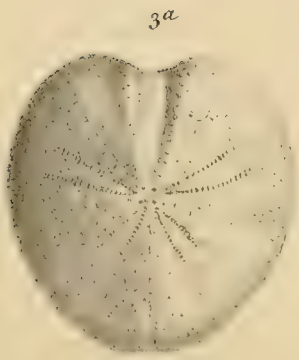
From the Lower Greensand.

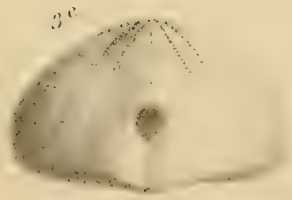
Fig. 3 *a*. Upper surface, natural size. British Museum. (P. 293.)
b. Lateral view, do.
c. Posterior view, do.











C.R.Bone del et lith.

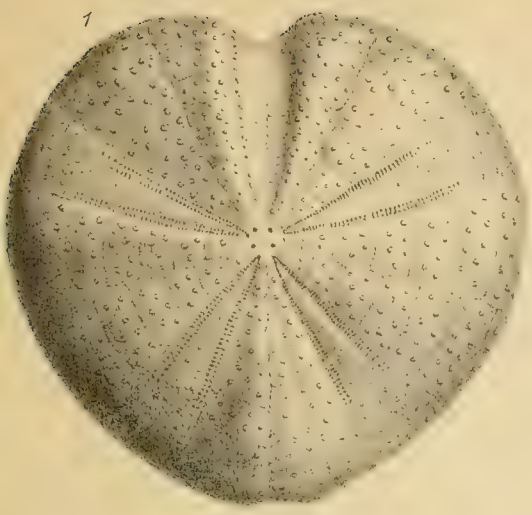
W.West & Co. imp.

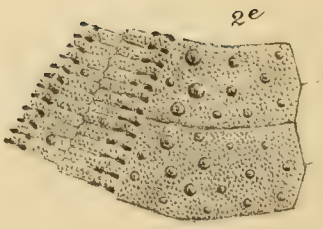
PLATE LXVII.

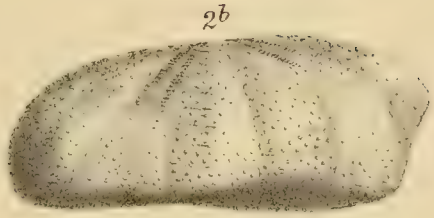
Cardiaster latissimus, *Agassiz.*

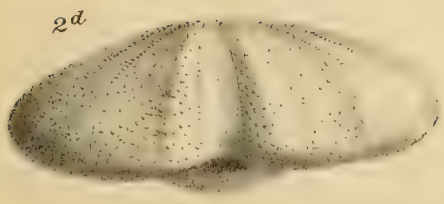
From the Upper Greensand.

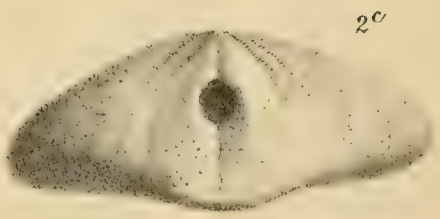
Fig. 1. Upper surface, natural size. My Cabinet. (P. 295.)
2 *a*. Under surface, natural size. Rev. T. Wiltshire's, F.G.S., Collection.
b. Lateral view do.
c. Posterior border do. with periprocte and vent.
d. Anterior do. do. with anteal sulcus.
e. Dorsal plates and primary tubercles with granules, magnified three times.
f. Ambulacral pores, magnified three times.
g. Primary tubercles from the base. Magnified.
h. Apical disc, magnified.











W. West & Co. imp

C.R. Bone delet lith

PLATE LXVIII.

Cardiaster fossarius, *Benett.*

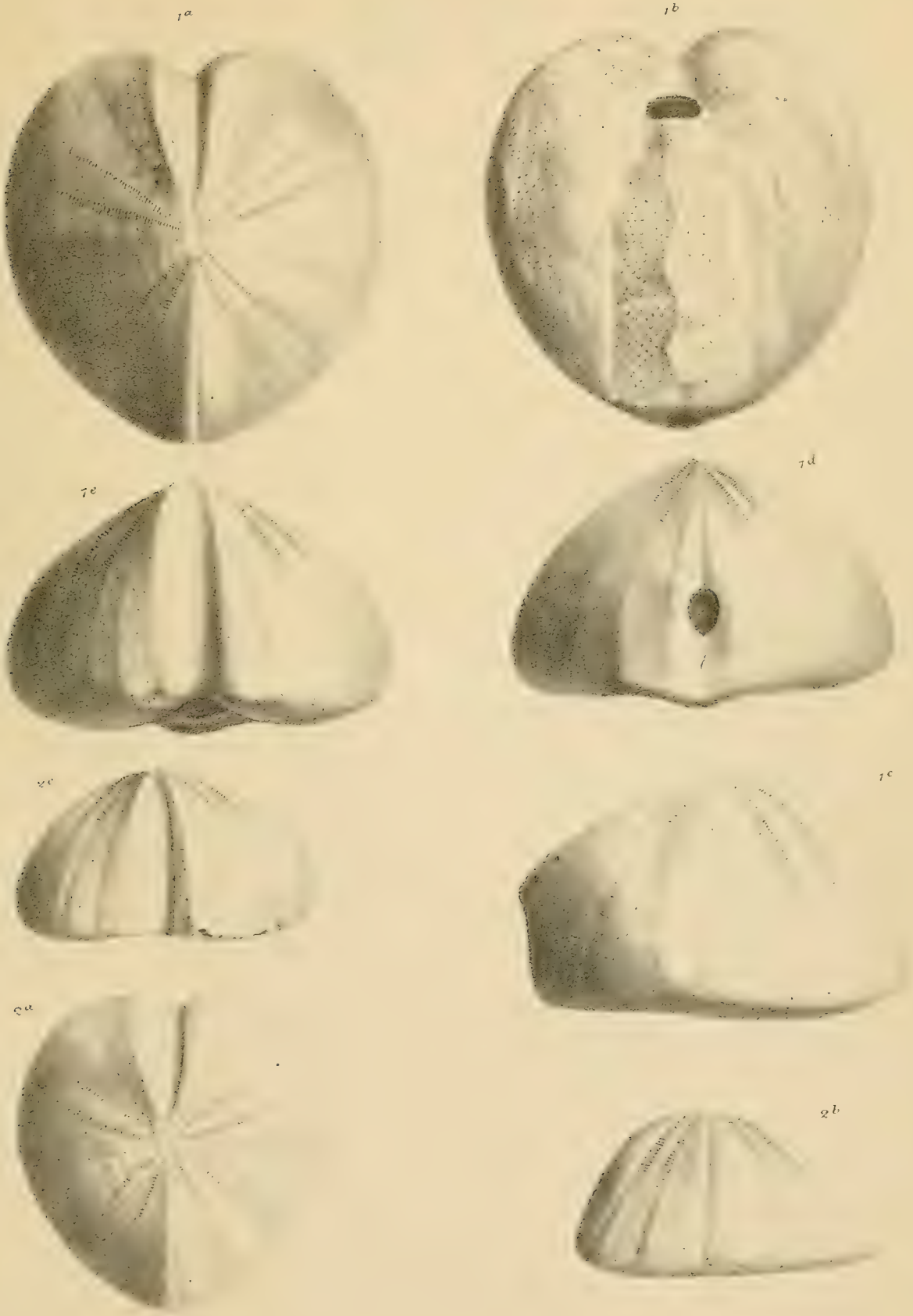
From the Upper Greensand.

Fig. 1 *a*. Upper surface, natural size. Cunnington collection. British Museum. (P. 297.)
b. Under surface do.
c. Lateral view do.
d. Posterior do. do.
e. Anterior border, do.

Cardiaster Perezii, *Sismonda.*

From the Upper Greensand.

Fig. 2 *a*. Upper surface, natural size. Jermyn Street Museum. (P. 299.)
b. Lateral view do.
c. Anterior border do. with anteal sulcus.



C.R.Bone del. et lith

W.West & Co. imp.

PLATE LXIX.

Cardiaster pygmæus, *Forbes.*

From the Upper Chalk.

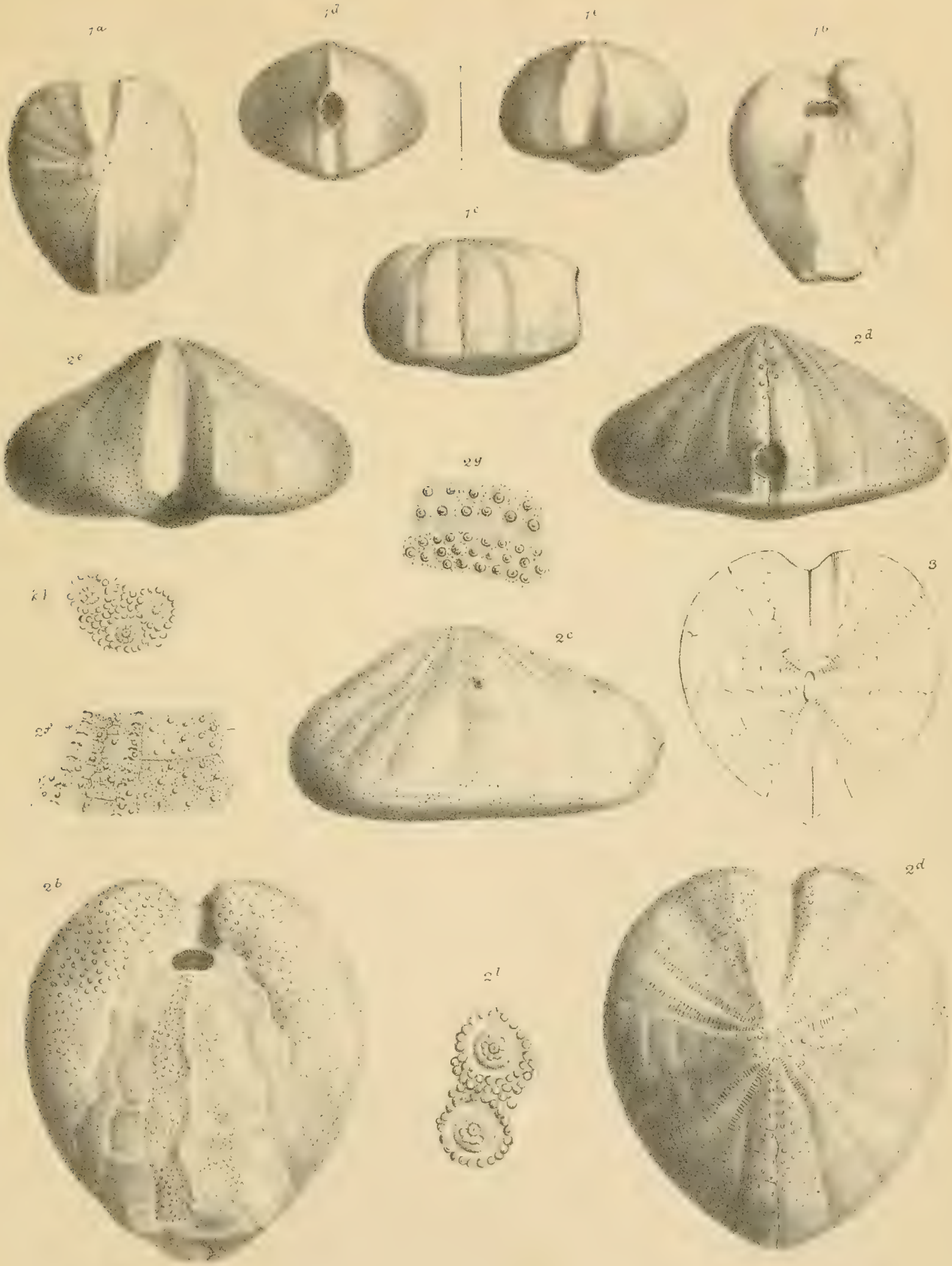
Fig. 1 *a*. Upper surface, magnified twice. Museum Royal School of Mines. (P. 301.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte, magnified twice.
e. Anterior border and anteal sulcus do.

Cardiaster granulosus, *Goldfuss.*

From the Upper Chalk.

Fig. 2 *a*. Upper surface, natural size. My Collection. (P. 302.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Plates with tubercles from upper surface, magnified.
g. Marginal plates with tubercles and marginal fasciole.
h. Tubercles from the dorsum, highly magnified.
i. Do. do. base do.

Fig. 3. Flint mould of *Cardiaster granulosus*.



C.R.Bone del. et lith.

W.West & Co. imp.

PLATE LXX.

Infulaster excentricus, *Rose*.

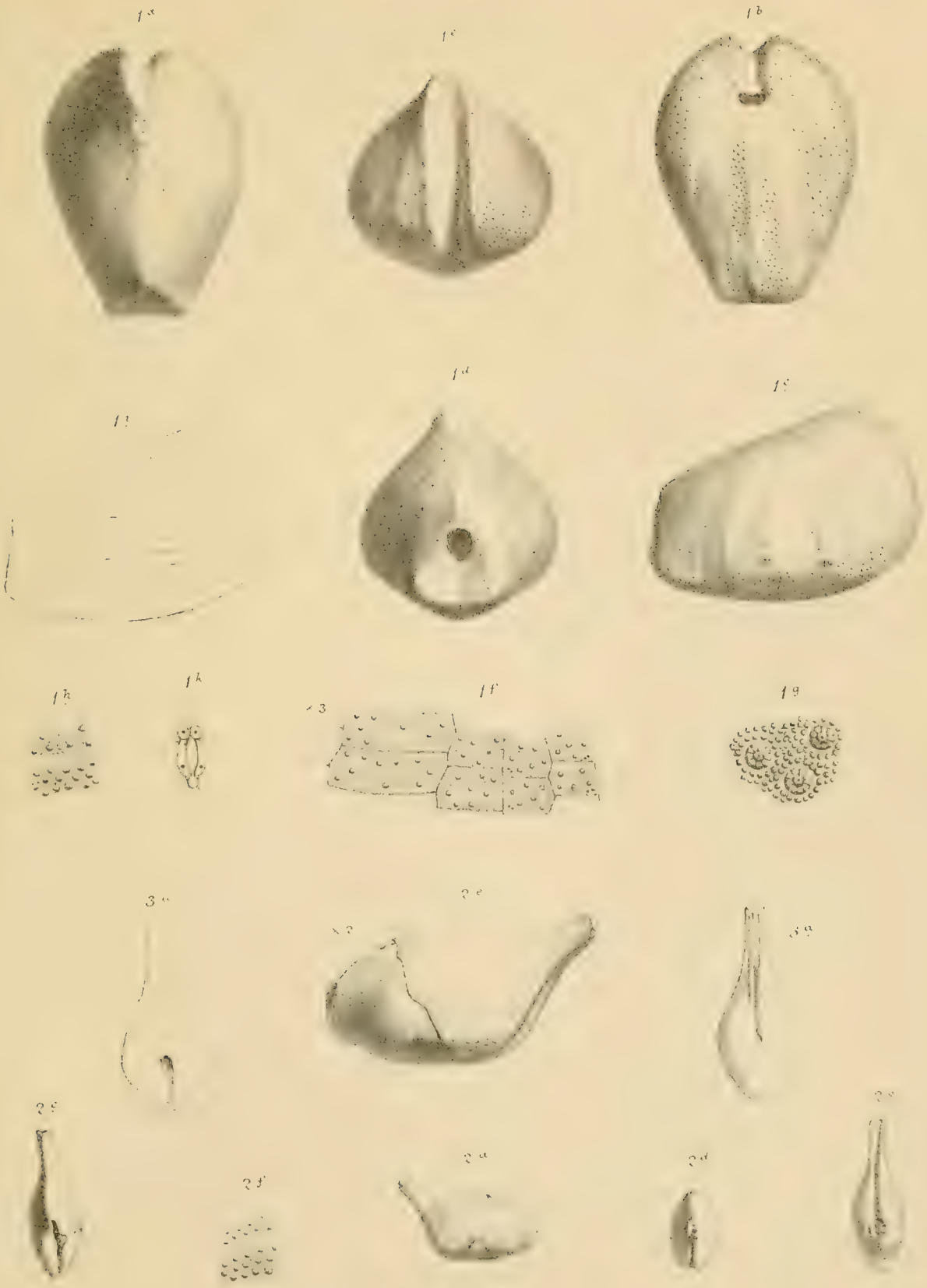
From the White Chalk of Norfolk.

Fig. 1 *a*. Upper surface, natural size. My collection. (P. 305.)
b. Under do. do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Surface sculpture of interambulacral plates, magnified three times.
g. Primary tubercles and encircling granules, highly magnified.
h. Part of the cheek, with a portion of the fasciole do.
i. Details of test and apical disc as shown in a flint mould, natural size.
k. The apical disc, highly magnified.

Infulaster rostratus, *Forbes*.

From the White Chalk near Plumstead.

Fig. 2 *a*. Lateral view, natural size. Museum, School of Mines. (P. 307.)
b., *c*., *d*., *e*. Different views of a specimen from Chalk near Plumstead.
f. Part of the cheek and fasciole. Museum, School of Mines.
Figs. 3 *a*. Outline, partly restored, of a large specimen from Norfolk Chalk, in the late Mr. Rose's Collection.



C.R. Bone del. et lith.

W. West & Co imp.

PLATE LXXI.

Cardiaster pillula, *Lamarck.*

From the White Chalk.

Fig. 1 *a*. Upper surface, natural size. Museum, School of Mines. (P. 325.)
b. Under do. do.
c. Lateral view, magnified two diameters.
d. Posterior border and periprocte, natural size.
e. Anterior do and anteal sulcus.
f. Part of the cheek with fasciole, magnified.
g. The elongated apical disc do.
h. Interambulacral plates, showing surface sculpture, highly magnified.
Fig. 2. Flint mould showing the poriferous zones.
Fig. 3 *a*. Flint mould of another specimen, showing position of the vent.
b. Anal plates for closing the periprocte.

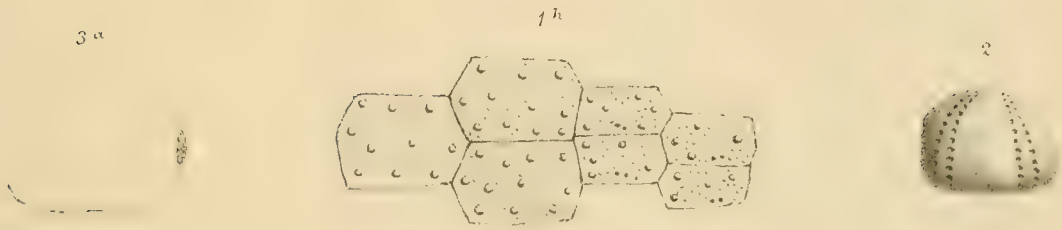
Cardiaster Benstedi, *Forbes.*

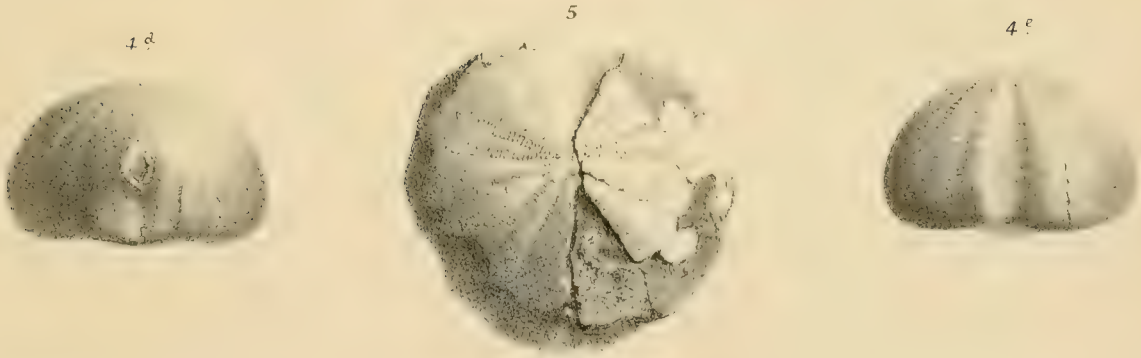
From the Lower Greensand.

Fig. 4 *a*. Upper surface, natural size. My collection. (P. 293.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte, natural size.
e. Anterior do. and anteal sulcus do.
Fig. 5. Large specimen showing poriferous zone.

1 c
× 2
1 d
1 e

1 a
1 a
1 f
3 b
1 b


3 a
1 h
2


4 d
5
4 c

4 b
4 c
4 a

PLATE LXXII.

Holaster lævis, *De Luc.*

From the Upper Greensand.

Fig. 1 *a*. Under surface, natural size. My collection. (P. 310.)
b. Upper do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Primary tubercles and granules, magnified.

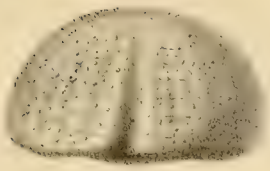
Holaster lævis *var.* planus, *Mantell.*

From the Lower Chalk.

Fig. 2 *a*. Under surface, natural size. My collection. (P. 317.)
b. Upper do. do.
c. Lateral view do.
d. Anterior border and anteal sulcus.
e. Posterior do. and periprocte.
f. Poriferous zones, magnified.

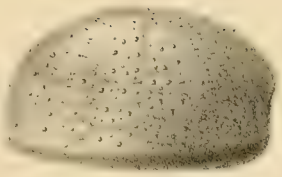
1a

1e



1b

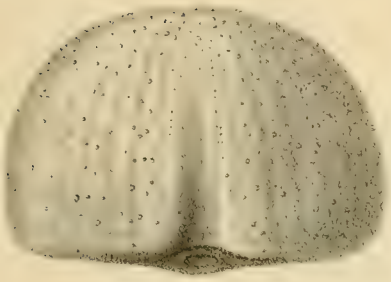
1c



1f

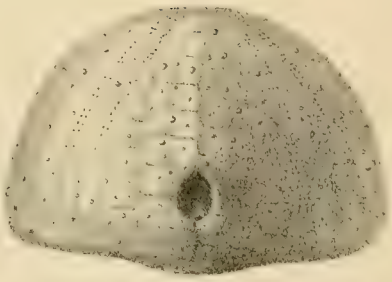
2f

2d

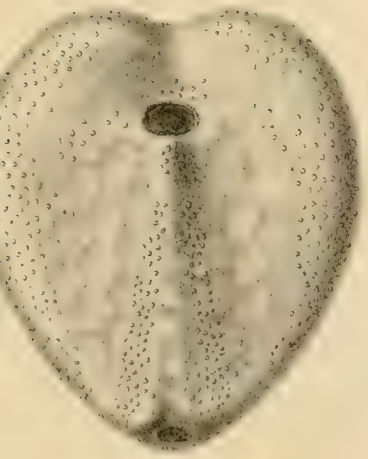


1d

2e



2a



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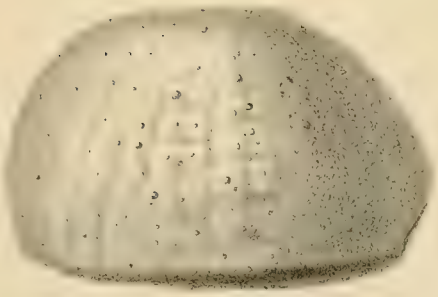

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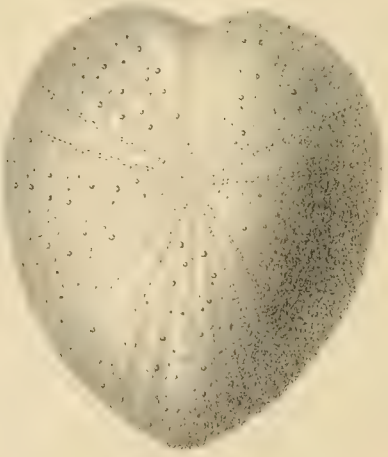
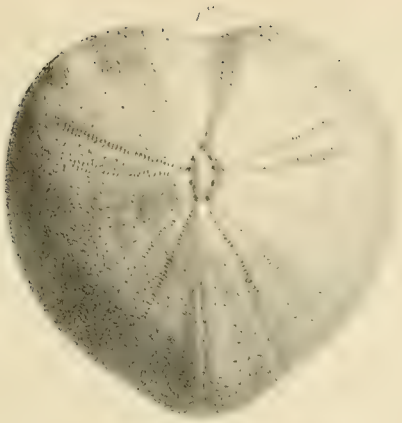


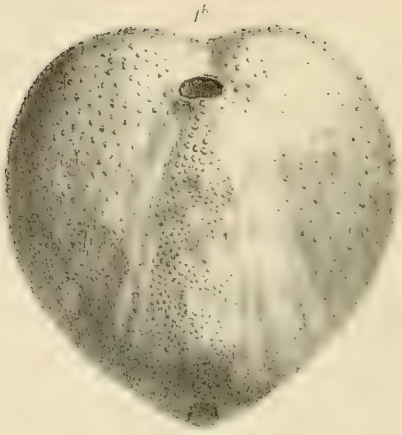
PLATE LXXIII.

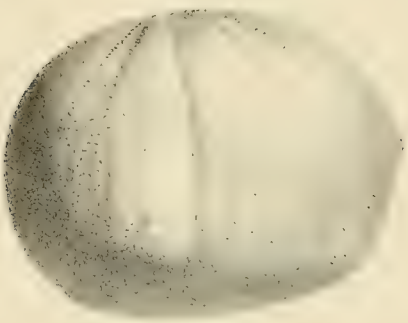
Holaster subglobosus, *Leske.*

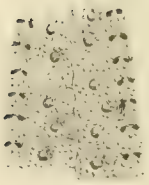
From the Lower Chalk.

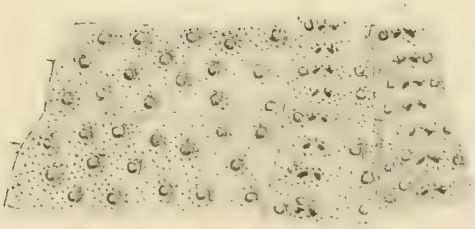
Fig. 1 *a*. Upper surface, natural size. My collection. (P. 319.)
b. Under do. do.
c. Lateral view do.
d. Posterior border and periprocte.
e. Anterior do. and anteal sulcus.
f. Apical disc, highly magnified.
g. Ambulacral and interambulacral plates, and poriferous zones, magnified three diameters, showing the regular surface sculpture.
h. Ambulacral area and poriferous zones, magnified three times.
i. Primary tubercles, with the scrobicular circles of granules highly magnified.

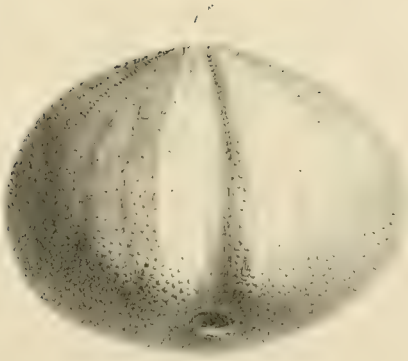


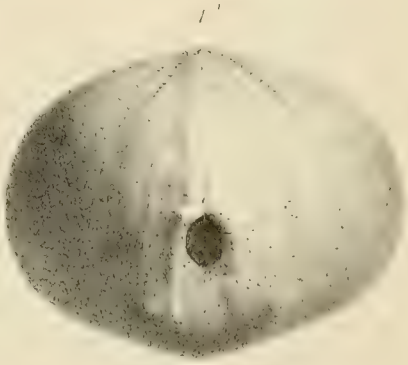












C R Bone del et lith

Vincent Brooks Day & Son, imp

PLATE LXXIV.

HOLASTER SUBORBICULARIS, *Defrance.*

From the Chloritic Marl.

Fig. 1 *a.* Upper surface, natural size. My collection. (P. 314.)
b. Under surface do.
c. Lateral view do.
d. Anterior do. do.
e. Posterior do. do.

HOLASTER TRECENSIS, *Leymerie.*

From the Lower and Grey Chalk.

Fig. 2 *a.* Upper surface, natural size. My collection. (P. 323.)
b. Under do. do.
c. Lateral view do.
d. Anterior do. do.
e. Posterior border showing the position of the periprocte.

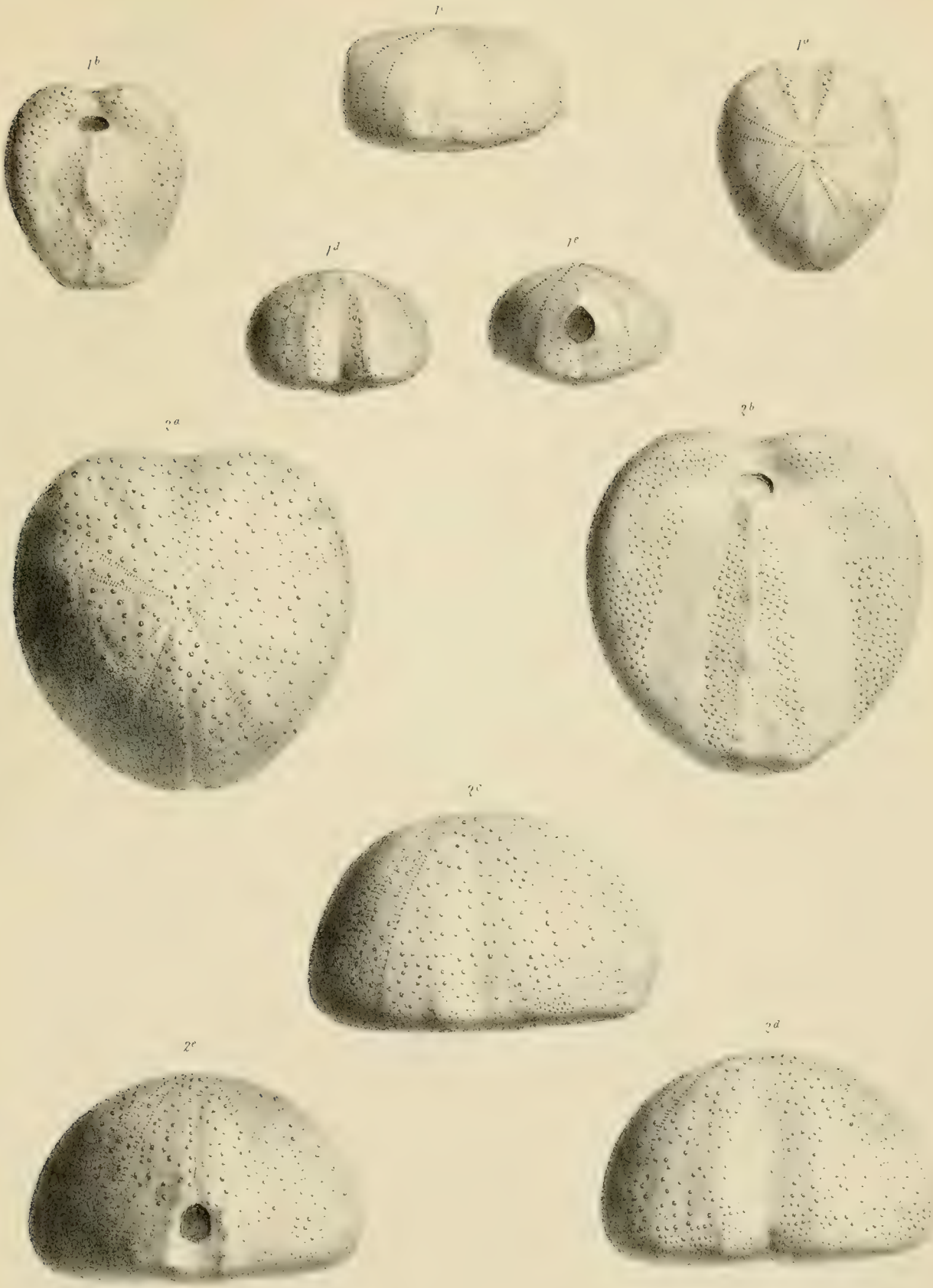

1a
1b
1c
1d
1e
2a
2b
2c
2d
2e

PLATE LXXV.

Echinospatagus Renevieri, *Wright.*

From the Lower Greensand, Shanklin Isle of Wight.

Fig. 1 *a.* Upper surface, natural size. Monsieur De Loriol's collection. (P. 285.)
b. Under do. do.
c. Lateral view do.
d. Primary tubercles, under surface.
e. Do. upper do.

Echinospatagus Quenstedtii, *Wright.*

From the Upper Greensand, Wiltshire.

Fig. 2 *a.* Upper surface, natural size. My collection. (P. 286.)
b. Under do. do.
c. Lateral view do.

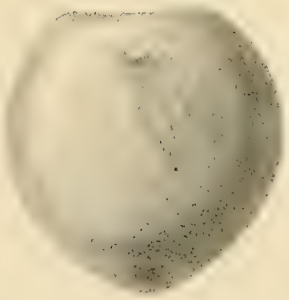
Micraster brevis, *Desor.*

From the Chalk of Corbières and Craie à Hippurites.

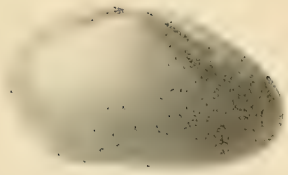
Fig. 3 *a.* Upper surface, natural size. My collection.
b. Under do. do.
c. Lateral view do.
e. Apical disc, and terminations of the ambulacra much enlarged.
f. Primary tubercles from the under surface, enlarged to show the deep areolæ and circles of granules.
g. Ambulacral area, poriferous zones, and interambulacral plates, enlarged three diameters, to show the structure of the surface sculpture of the test.
Fig. 2 *d.* Non-petaloid portion of the ambulacra.

1a

1b



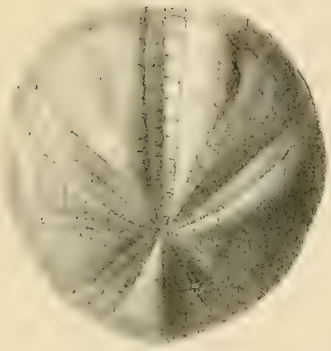
1c



1d

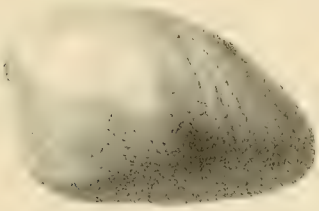
1e

2a



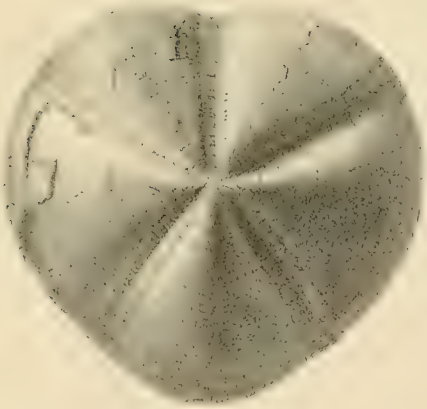
2b

2c



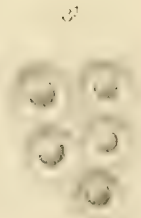
2d

3a

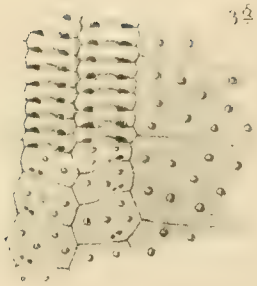


3b

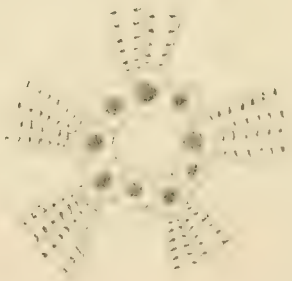
3c



3d



3e



GL.Griesbach del et lith.

Hanhart imp

PLATE LXXVI.

The German type-form from Weddingen, near Hanover.

Fig. 1 *a*.	MICRASTER COR-TESTUDINARIUM, *Goldfuss*.			Upper surface, natural size. My collection. (P. 335).
1 *b*.	—	—	—	Lateral view, do.
1 *c*.	—	—	—	Under surface, do.
1 *d*.	—	—	—	Ambulacral area, poriferous zones, and interambulacral plates, magnified.
1 *e*.	—	—	—	Primary tubercles in granulated surface, magnified.
1 *f*.	—	—	—	Primary tubercles, under side, magnified.

English specimen type-form from Purley, Surrey.

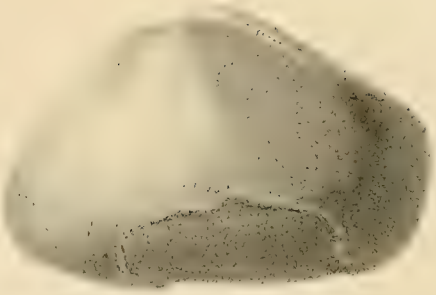
2 *a*.	MICRASTER COR-TESTUDINARIUM, *Goldfuss*.			Upper surface, natural size. My collection.
2 *b*.	—	—	—	Under surface, do.
2 *c*.	—	—	—	Petaloidal ambulacra and poriferous zones, magnified.
2 *d*.[1]	—	—	—	Apical disc, showing the circle of ovarial and ocular plates, with the summits of the ambulacra magnified.
2 *e*.	—	—	—	Primary tubercles on upper surface, with granules on plates, magnified.

[1] Written 1[d] in error on the Plate.

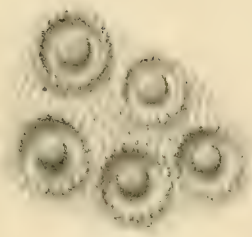
1a

1c

1b



1f



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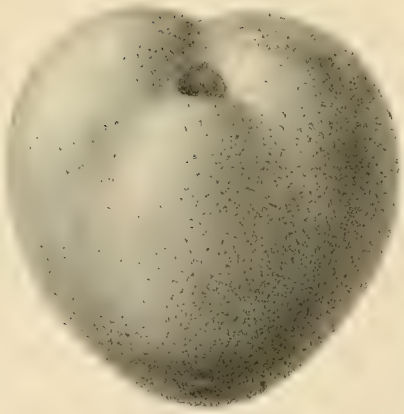

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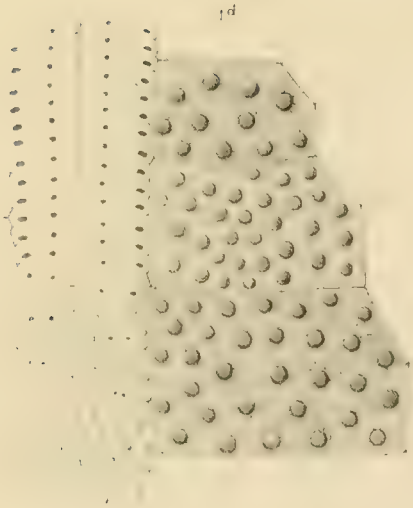
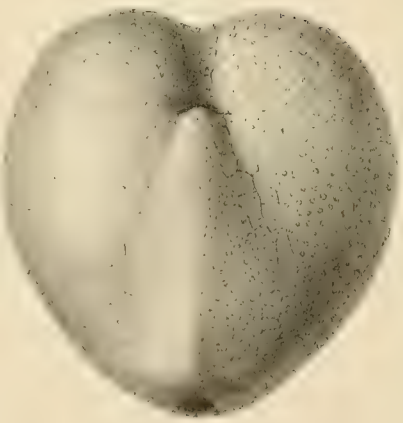


2c

2a

1d

2b



2e

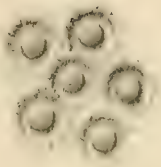


PLATE LXXVII.

Fig. 1 *a*. ECHINOCORYS VULGARIS, *Breynius*. Posterior border, showing marginal vent. The type-form. My collection. (P. 328).

1 *b*. — — — Under surface, showing mouth and vent. The type-form.

1 *c*. — — — Lateral view, showing ambulacra and interambulacra with poriferous zones. The type-form.

1 *d*. — — — Apical disc, showing ovarial and ocular plates *in situ*.

1 *e*. — — — Peristome, showing ambulacra and large tubercles radiating therefrom.

1 *f*. — — — Ambulacral and interambulacral plates, near the summit (upper figure), and ambulacral and interambulacral plates, from the sides of test (under figure).

1 *g*. — — — Tubercles and granules of the upper surface.

1 *h*. — — — Tubercles and granules from the lower surface.

2. — PYRAMIDATUS, *Portlock*. Type-specimen outline. School of Mines Museum.

3. — — — Unsymmetrical form of this variety.

4. — OVATUS, *auctorum*. Elongated and depressed form. My collection.

5. — GIBBUS, *Agassiz*. My collection.

6. — PYRAMIDATUS. Tumid unsymmetrical variety. My collection.

7. — STRIATUS, *auctorum*. A very elevated example. do.

8. — PYRAMIDATUS. Tumid and unsymmetrical example. do.

9. — OVATUS, *Leske*. French example, common. do.

10. — VULGARIS. Flint mould, under surface, showing lines of poriferous zones. My collection.

11. — — Flint mould, upper surface, showing impressions of the apical disc, the position of the ovarial and ocular apertures, and furrow indicating the position of the base of the sand canal.

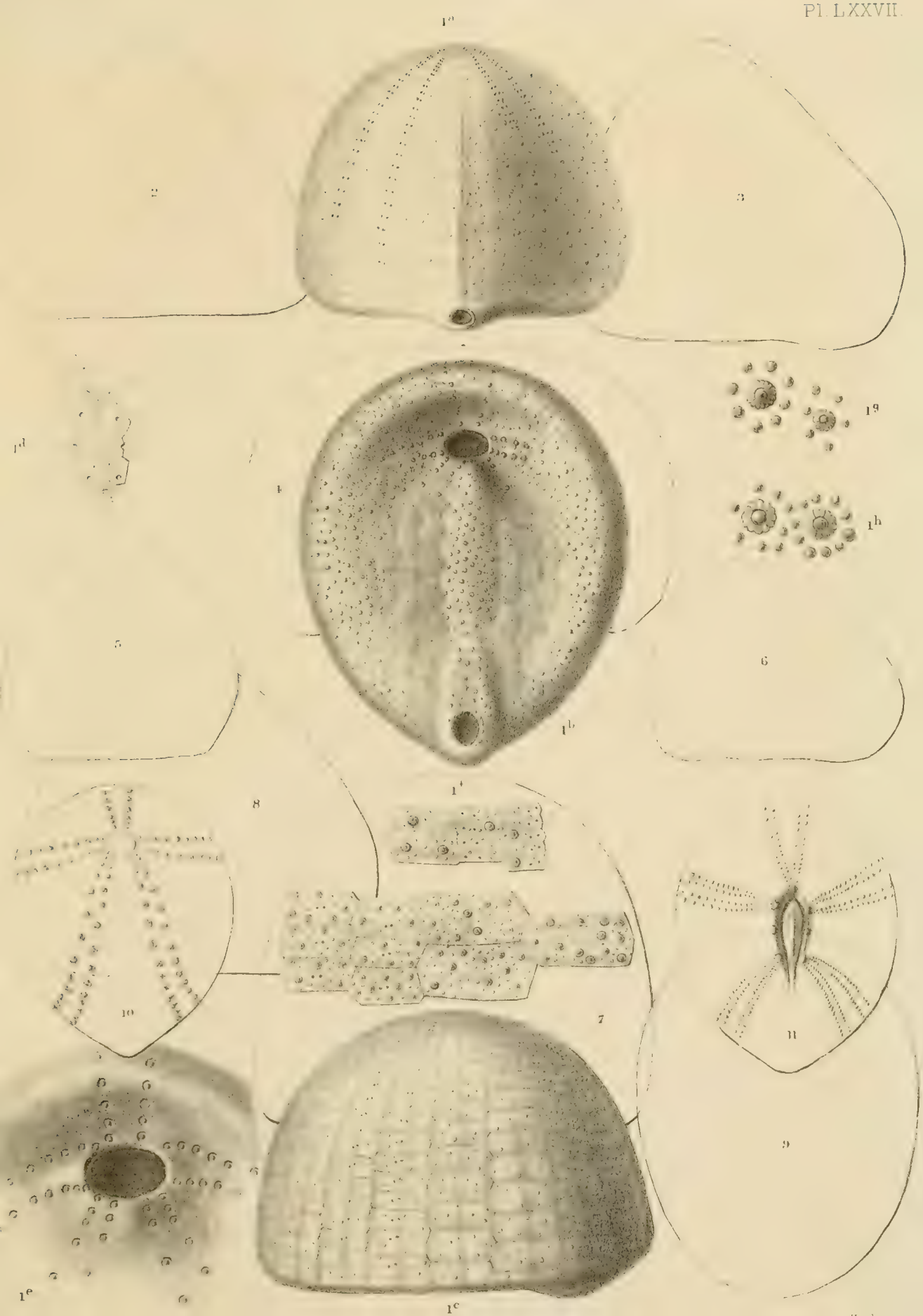

1a
2
3
1d
4
1g
1h
5
6
1b
1f
8
10
7
11
9
1e
1c

PLATE LXXVIII.

Fig. 1 *a*. Holaster obliquus, *Wright*. Under surface, natural size. My collection. (P. 313.)

1 *b*. — — — Upper surface, natural size, showing the excentral position of the apical disc.

1 *c*. — — — Lateral view, showing the obliquity of the test.

1 *d*. — — — Posterior border, showing the central position of the vent.

1 *e*. — — — Anterior border, showing the anteal sulcus and tubercles and posterior border.

2 *a*. Catopygus pyriformis, *Goldfuss*. Upper surface and thimble-like depressions magnified three times. Museum, School of Mines. (P. 340.)

2 *b*. — — — Posterior border, with anal area and periprocte magnified. do. do.

2 *c*. — — — Under surface, showing mouth with lobes and petaloidal oral leaves. do. do.

3 *a*. Echinobrissus lacunosus, *Goldfuss*. Upper surface magnified four diameters. My collection. (P. 249, 250.)

3 *b*. — — — Under surface magnified, showing petaloidal oral expansions.

The figured specimen was obtained from the "Craie Chloritée de la Sarthe."

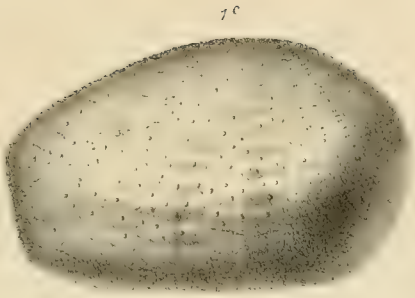
4 *a*. Echinobrissus Morrisii, *Forbes*. Upper surface, highly magnified. My collection. (P. 250.)

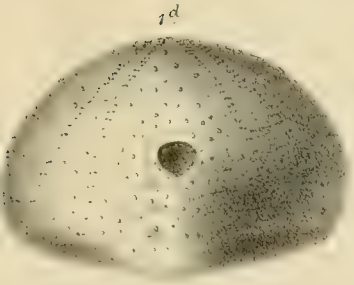
4 *b*. — — — Under surface, highly magnified.

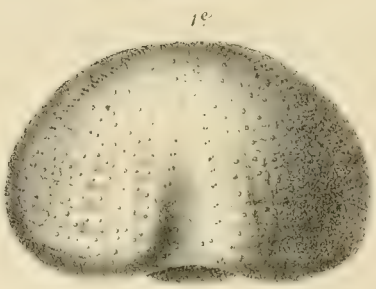
The figured specimen was collected from the Chloritic Marl, Chardstock.

1a

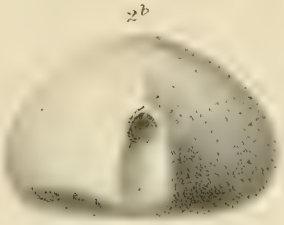
1b


1c


1d

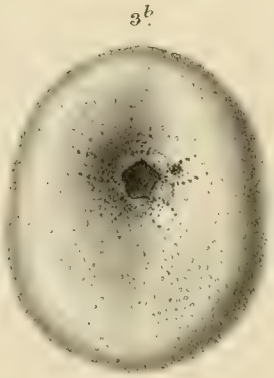

1e

2a


2b

2c

3a


3b

4a

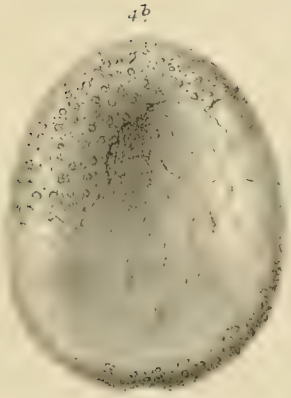

4b

PLATE LXXIX.

Fig. 1 *a b.* Holaster lævis, *var.* planus, *Mantell.* Flint, with moulds of this species, showing its gregarious character and stratigraphical position in the Chalk with flints, Lewes. Natural size. Collection of the Rev. Prof. T. Wiltshire, F.G.S. (P. 317.)

2 *a.* — subglobosus, *Leske.* Posterior border, natural size, showing a small variety of test from the Red Chalk of Speeton, inflated at the ambitus, and truncated posteriorly. Natural size. Collection of the Rev. Prof. T. Wiltshire. (P. 319.)

2 *b.* — — — Upper surface.

3 *a.* Cardiaster fossorius, *Benett.* Posterior surface, natural size, showing the narrow posterior border; anal area and high position of the vent, an extremely sharp angular variety. Cherty cast, from Lyme Regis. Collection of the Rev. Prof. T. Wiltshire. (P. 297.)

3 *b.* — — — Upper surface of the same test, natural size, showing the deep anteal sulcus with angulated borders and central position of apical disc.

4 *a.* Holaster obliquus, *Wright.* Posterior border. Natural size. Red Chalk of Hunstanton. Collection of the Rev. Prof. T. Wiltshire. (P. 313.)

a b. — — — Upper surface, showing test covered with small tubercles.

3a

2a

4a

2b

3b

4b

1a

1b

PLATE LXXX.

Fig. 1. PSEUDODIADEMA FRAGILE, *Wiltshire*. Exterior surface of an interambulacral plate, magnified eight diameters.

2. — — — Under surface of test, somewhat crushed and broken, natural size.

3. — — — Spine, natural size.

4. — — — Portion of surface of spine, magnified sixteen diameters.

5. — — — Interior surface of a plate, magnified four diameters.

6. — — — Under surface plates of ambulacral and interambulacral areas, magnified four diameters.

7. — — — Upper surface of test, natural size.

8. — — — Spine, magnified eight diameters.

9. — — — Section of interambulacral plate (Fig. 1), passing through the primary tubercle.

10. — — — Transverse section of spine (Fig. 3), magnified twenty diameters.

The specimens figured are from the collection of the Rev. Prof. Thos. Wiltshire, F.G.S.

Fig 1

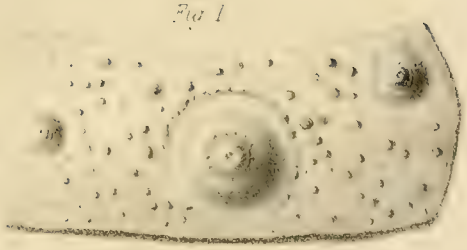


Fig 4

Fig 3

Fig 2

Fig 5.

Fig 6

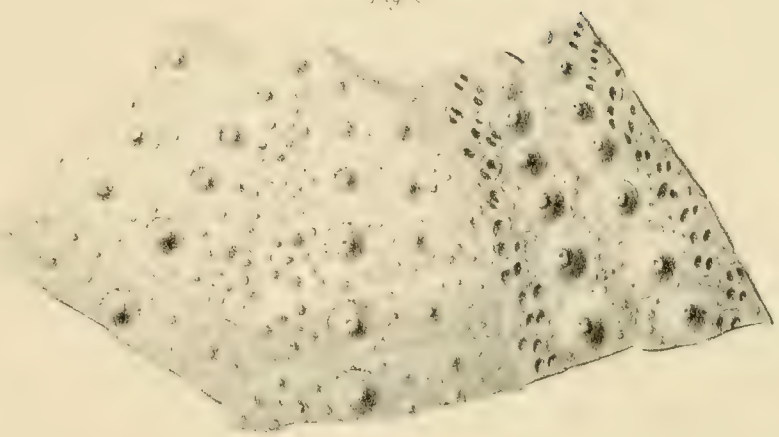


Fig 7

Fig 8

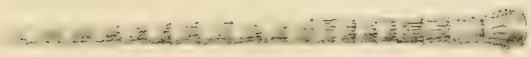
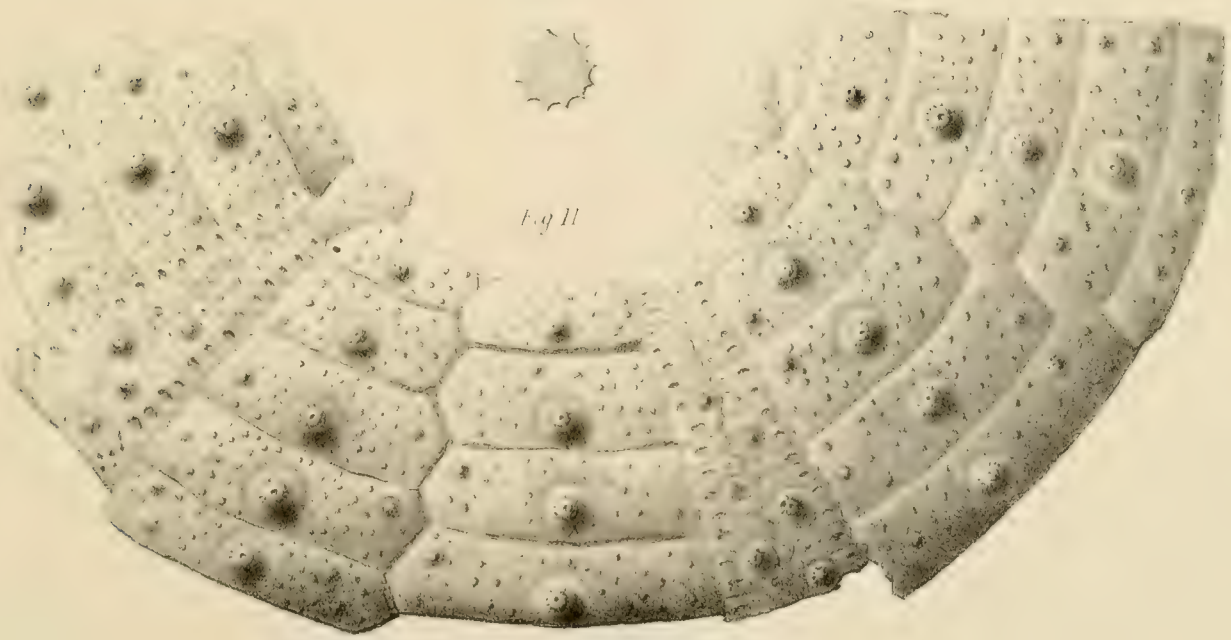


Fig 9

Fig 10

Fig 11



3 9088 00727 3584